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Cost-effectiveness analysis of a Community Paramedicine Program for low-income seniors living in subsidized housing: The Community Paramedicine at Clinic Program (CP@clinic)

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ABSTRACT

Objectives: To evaluate the cost-effectiveness of CP@clinic compared to usual care in seniors residing in subsidized housing.
Design: A cost-utility analysis was conducted within the context of a large pragmatic cluster randomized controlled trial (RCT). Subsidized housing buildings were matched by socio-demographics and location (rural and urban), and were allocated to intervention (CP@clinic for 1 year) or control (usual care) via computer-assisted paired randomization.
Setting: Thirty-two subsidized seniors' buildings (social housing) in Ontario.
Participants: Building residents 55 years and older.
Intervention: CP@clinic is a community paramedic-led, chronic disease prevention and health promotion program offered weekly in the building common areas. CP@clinic is free to all residents and includes risk assessments, referrals to resources, and reports back to family physicians.
Outcome measures: Incremental cost effectiveness ratio (ICER) based on total program costs and changes in quality-adjusted life years (QALYs) measured with EQ-5D-3L. QALY change was analysed between groups post-intervention, controlling for pre-intervention values and building pairings. Data on program costs were collected prior to inception and during implementation. Cost associated with emergency medical service (EMS) use were also estimated.
Results: The RCT included 1461 residents; 146 and 125 seniors completed the EQ-5D-3L in intervention and control buildings, respectively. Differences in QALYs between groups were significant; unadjusted mean QALY gain was 0.06 (95%CI: 0.01-0.12); adjusted mean QALY gain was 0.04 (95%CI: 0.01-0.07) in the intervention group. Total program cost for implementing in five communities was CAN$128,462 and the reduction in EMS calls avoided an estimated CAN$256,583. The ICER was CAN$2,200/QALY but could be even more cost effective after accounting for the EMS call reduction.
Conclusion: The CP@clinic ICER was well below the commonly used Canadian cost-utility threshold of CAN$50,000. CP@clinic scale-up across subsidized housing is feasible and could result in better health-related quality-of-life and reduced EMS use in low-income seniors.

Strengths and limitations of this study:

- the study is an economic evaluation of a community paramedicine program
- community paramedicine programs are infrequently evaluated from a health economic perspective
- this study adopts the perspective of the paramedic service that might implement such a program
- this evaluation did not include long-term implications of the program and therefore may have underestimated its economic value
- a uniform cost was applied for EMS use despite potential differences due to service or type of call, therefore slight variations in cost remain unaccounted

INTRODUCTION

Community Paramedicine (CP) is an emerging field that is actively expanding across Canada. Community paramedics are deployed in non-traditional, non-acute response settings, which can involve health promotion and disease prevention activities.[1] This new paramedicine role has already demonstrated having a positive impact on the quality of life and health of vulnerable populations,[2,3] while also reducing utilization of emergency medical services.[2,3] In addition, there are potential benefits to the health and wellbeing of paramedics who take on CP roles. [4-6] Though community paramedicine models are emerging widely, evaluation of these programs and activities is rare and those that do exist lack rigour.[1] Evaluation of CP programs should include economic evaluations in order to drive and inform policy change in health authorities. Where these economic evaluations can take account of staffing models, such as modified or non-modified/regular staff, it is even more applicable to healthcare planning.

Though some community paramedicine programs from differing contexts have been evaluated for cost-effectiveness, a recent review for Alberta Health Services concluded that the cost-effectiveness of the CP trials included in their study was not readily generalizable to other settings due to differences in program models.[7] The programs that had a cost-effectiveness evaluation constituted one involving an on-site nurse practitioner-paramedic collaboration and off-site family physician for patients over 40 years of age with chronic disease, and another with a paramedic practitioner for patients over 60 years of age. A recent study conducted in Renfrew County, Ontario, performed an economic evaluation of a home visit program model (Aging at Home) and was able to demonstrate an incremental cost per quality-adjusted life year (QALY).[8] However, no studies have evaluated the cost-effectiveness of a wellness or clinic style community model of community paramedicine.

The Community Paramedicine at clinic program (CP@clinic) has been evaluated in the format of a rigorous randomized controlled trial (RCT), in which it was found to have positive effects on the reduction of EMS calls from implementation sites.[2,3] We sought to evaluate the cost-effectiveness of the CP@clinic program compared to usual care for low-income seniors living in subsidized (social) housing using a cost-utility analysis. The perspective of the paramedic service was chosen since it is the implementer of such community programs, and can receive funding from multiple sources, both Ministry and Public payer, depending on its geographic location. Therefore, the paramedic service perspective is the most transferrable, and they would require this type of information to determine future implementation.

METHODS

Design and Setting: This cost-utility analysis (with multiple sensitivity analyses) was conducted from the perspective of paramedic services within the context of a large pragmatic cluster RCT in 2015/2016 for which the protocol [9] and results [3] have been published elsewhere. The one-year RCT evaluated the CP@clinic program in subsidized housing for seniors (aged 55 and older) in five communities across Ontario, Canada. The cost-utility analysis was conducted alongside the trial, using quality-of-life measures that could be translated into comparable outcomes. Ethical approval was obtained through the Hamilton Integrated Research Ethics Board (study numbers #14-210 and #14-645). Twenty-six subsidized seniors' buildings, matched by socio-demographics and location (rural and urban, Ontario), were allocated to intervention (CP@clinic for 1 year) or control (usual care) via computer-assisted paired randomization.

Intervention: Weekly CP@clinic health risk-assessment and health promotion sessions were delivered at buildings by community paramedics. A full description of the CP@clinic program is available elsewhere.[2] In brief, paramedics conducted weekly sessions within common areas of subsidized housing buildings. Residents drop-in to the sessions and have health risks measured, receive tailored health education and results are communicated with their family physician. Control buildings received usual care as the comparator.

Main Trial Results: As published previously, the CP@clinic RCT demonstrated significantly reduced EMS calls after 1 year of implementation when adjusted for the study design (i.e. building pairing) and baseline calls.[3] Comparing intervention and control buildings, there was an adjusted mean monthly difference of -0.90 calls per 100 apartment units per month (95%CI = -1.54 to -0.26), which translates to an estimated 10.8 fewer EMS calls per 100 apartment units per year (see Table 1). Since the intervention buildings had 1461 units, it can be estimated that 157.8 EMS calls were avoided during the intervention period.

Table 1: Difference in emergency medical service call rates for intervention and control buildings (main trial results)

	Intervention Buildings Mean (SD)	**Control Buildings** Mean (SD)	**Mean Difference (95% CI)**
Baseline: Unadjusted monthly EMS calls per 100 units	4.13 (2.79)	4.60 (2.80)	-0.47 (-1.12 to 0.18)
After 1 year: Unadjusted monthly EMS calls per 100 units	3.67 (2.75)	4.79 (2.93)	-1.12 (-1.78 to 0.46)
Unadjusted: Monthly Mean Difference	-0.47 (3.83)	0.19 (3.57)	-0.65 (-1.51 to 0.20)
Adjusted:** Monthly Mean Difference	------	-----	-0.90 (-1.54 to -0.26)*
Expected annual decrease in 911 calls: 10.8 calls / 100 apartment units / year			

Notes: EMS = Emergency Medical Service; n = 26 buildings (13 pairs of intervention and control buildings);
* p < 0.006; ** adjusted for building pairing and pre-intervention baseline

In addition, the CP@clinic intervention had a positive effect on resident health-related quality of life in the intervention buildings, compared to the control buildings (see Table 2); this is a building-level result that includes individuals from the intervention buildings, regardless of whether or not they opted to attend the program sessions.

Table 2: Difference in QALY for intervention and control buildings

	Intervention Building Residents versus Control Building Residents		
	Intervention Mean (SD) n=358	**Control Mean (SD) n=320**	**Mean Difference (95% CI)**
Unadjusted QALY gain: Mean difference in EQ-5D index score over 1 year	0.10 (0.39)	0.04 (0.38)	**0.06* (0.01, 0.12)**
Adjusted QALY gain: Mean difference in EQ-5D index score over 1 year	0.05 (0.19)	0.01 (0.23)	**0.04* (0.01, 0.07)**

Notes: QALY = Quality Adjusted Life Year; *p < 0.05; Intervention and Control were found to be significantly different at baseline, despite randomization, therefore baseline differences were accounted for by adjustment; multiple imputation used to handle missing data

Data were collected on quality-of-life from intervention and control building residents before (between October 2014 and December 2015) and after the program (between December 2015 and December 2016). The data collection timing reflected the staggered nature of the RCT starts dates in each site, though at least 12 months was allowed between the before and after surveying. We used the EuroQol Quality of Life Measurement Tool, EQ-5D 3L, by permission.[10] Participants were invited to complete the survey through invitation posters that were displayed throughout the building, and flyers that were handed out to residents, describing the day and time that the research team would be present to administer the questionnaires. After obtaining informed written consent, data collection was performed by trained research assistants, on paper, due to low educational levels and poor health literacy of participants.[11] The research assistant read each question to the participant, including the answer categories and prompts, and noted the participant's responses. A consecutive sampling method was used, due to the difficulty of surveying in this vulnerable population.[11] Upon completion, the participants were provided with a local grocery gift card worth $10.

Over the course of the 1-year intervention, there was an unadjusted 0.06 QALY gain per person (95% CI, 0.01 to 0.12) in favour of the intervention buildings. When adjusting for baseline differences in the EQ-5D index score between the intervention and control buildings, there was a significant adjusted mean 0.04 QALY gain per person (95% CI, 0.01 to 0.07). When restricted to those who attended the program (n=595), there was an adjusted mean 0.06 QALY gain per person (95% CI, 0.02 to 0.10) for intervention attendees compared to the control building residents.

Data Collection

All costs presented are in Canadian Dollars for the 2016 year and represent the costs to the paramedic service implementing CP@clinic (program and staffing costs).

Program Costs:

In all communities that took part in the CP@clinic RCT it was found that the local housing authority routinely did not charge for space when other publicly funded or nonprofit organizations were providing health and wellness programming to residents. It is not within the mandate of regional or municipal housing organizations to provide health-related services,[14] but they recognize the value of these types of programs for residents, so they welcomed CP@clinic using the space in-kind. Direct program costs of running CP@clinic included the vehicle to transport the community paramedics between their base and each of the intervention buildings, technology-related costs (software, information technology support, database administration, and YubiKey), and session equipment (laptop, weighing scale, tape measure, blood glucose measurement items, WatchBP Office blood pressure monitoring device, and a carry bag).

Staffing Costs:

Paramedic services are responsible for all of these costs. These included salaries, materials for session implementation and technology-related costs. Where possible, costs were obtained from the source from which the service, object or goods were obtained. Detailed records were kept of all materials required for the implementation of the program. These records were validated with community paramedic supervisors. Staffing hours and salary levels were also verified with paramedic services. Paramedic salary hourly costs were obtained from paramedic services implementing CP@clinic and where unknown, the highest salary from other services was used. The combined hourly cost of supervision and administration within the paramedic service to oversee the community paramedics was estimated at 200% of paramedic hourly salary with benefits based on information provided by the services. Paramedic vehicle and vehicle-related costs (i.e. mileage to cover maintenance and fuel) were also obtained from the paramedic services directly. Since the paramedic services implementing CP@clinic had different paramedic salary rates, staffing models (dedicated community paramedics versus paramedics on modified duty), and vehicle-related costs, the **total actual costs for all five RCT sites together were used to evaluate cost-effectiveness**. Also, in order to inform paramedic services considering implementing CP@clinic in the future, the costs for each staffing model observed during the RCT have been presented as a sensitivity analysis with three potential staffing models:

1) Model 1 (minimum): Two paramedics staffing CP@clinic, both on 'modified' duties, therefore not requiring additional salary costing; 1 hour per week of administrative time; and other staffing (e.g. database management) provided in-kind or funded by external sources.

2) Model 2 (moderate): Two paramedics staffing CP@clinic, but one paid as a community paramedic, and one on modified duties; 1.5 hours per week of administrative time, and the cost of other staffing split 50/50 between the paramedic service and external/in-kind funding.
3) Model 3 (maximum): Two paramedics staffing CP@clinic, both paid as community paramedics; 2 hours per week of administrative time, and the full cost of other staffing being paid for by the paramedic service.

Since the paramedic service perspective has been taken, the healthcare costs examined in this paper do not go beyond the EMS call (e.g. hospital admissions, duration of stay, specialist visits). Data on the number of EMS calls avoided were taken from the RCT results (see Table 1), which found that the intervention buildings had 10.8 fewer calls per 100 apartment units post-intervention, compared to control buildings. The costs (in Canadian dollars) estimated for potential EMS call offset were obtained from Canadian literature in 2017 where we found $499/call to be a minimum cost, $1626/call to be a moderate cost, and $2254/call to be the maximum cost.[12] Inflation according to the Consumer Price Index for Healthcare, [15] was not required since the one-year intervention was in 2015/2016. The base case cost-utility analysis was conducted without any cost offset from the avoided EMS calls and then a sensitivity analysis was conducted using a range of potential cost offsets depending on the value assigned to the average EMS call.

Outcomes

The cost-effectiveness outcomes were analyzed and presented as incremental cost-effectiveness ratios (ICERs) of the intervention (CP@clinic) versus control (usual care). Cost-effectiveness, in the form of a cost-utility analysis, was evaluated based on the cost of implementing and maintaining the CP program and QALYs as the measure of effectiveness; sensitivity analyses also included EMS calls avoided in the ICER calculation. ICERs were presented where appropriate (when the intervention was not dominant/dominated). The time horizon of the analysis was 12 months, therefore discounting techniques were not used.

Analysis

The value of the total number of QALYs was calculated by computing the mean number of QALYs gained per resident during the program period (1-year). Missing QALY values were calculated using multiple imputation techniques (iterative Markov chain Monte Carlo method).

Cost of the program per resident was calculated by dividing the total program cost (summation of all program expenses) divided by the number of units in the intervention buildings. This provided a conservative estimate of the cost per resident since over 90% of units only had one resident [3]; as the number of residents per unit increases, the cost per resident decreases, therefore assuming one resident per unit is the most conservative approach to estimating the cost per resident with fluctuating building resident numbers. The incremental cost per QALY was the ratio of the difference in cost of the CP@clinic per building resident compared to the control group ($0 was assumed because there was no program added) divided by the difference in mean QALY gained in the intervention group compared to the control group. In addition, sensitivity analyses for the incremental cost per QALY were calculated based on the range of costs that could be assigned to each EMS call avoided.

We used the ICER threshold of $50,000 CDN per QALY, which has been suggested as a conservative lower boundary for a willingness to pay threshold.[13]

The program cost per EMS call avoided was the ratio of total program cost over the total number of EMS calls avoided. Finally, the potential net cost for a future site wanting to implement the CP@clinic program in two buildings and in four buildings was calculated for each of the three different staff costing scenarios and each of the three cost-offset scenarios.

RESULTS

Program Costs

Direct costs: The direct program cost of CP@clinic per community was $12,962, and the overall direct program cost for the five communities in the RCT was $64,810, excluding staffing. Please see Table 3 for the list of costs per item and source.

Table 3: Direct Program Costs in Canadian Dollars (excluding staffing)

Item	Source	Cost per site ($ CAD in 2016)
Space	Housing authority of each community	In-kind
Vehicle incl. fuel and maintenance	Paramedic service of each community	10,000
Information technology supports and overheads	McMaster University, DFM IT	500
Database software	McMaster University, DFM IT	235
YubiKey	McMaster University, DFM IT	53
Printing and materials (e.g. posters, flyers, BP record card)	McMaster University Media Services	253
Session Equipment:		
Laptop	McMaster University, DFM IT	726
Weighing scale	Medical supply vendor	240
Tape measure	Medical supply vendor	5
BP machine (WatchBP Office)	Medical supply vendor	750
Glucometer, lancets, swabs, bandages	Paramedic service of each community	150
Carry Bag	Office supply vendor	50
	Direct program costs per community:	12,962
	Total direct program costs for all five RCT study sites:	**64,810**

Notes: BP = Blood pressure; DFM IT = Department of Family Medicine Information Technology; RCT = Randomized Controlled Trial

Staffing costs**:** Each site had different staffing arrangements during the RCT, such as rate of pay, number of buildings receiving the intervention, and number of paramedics on modified duties staffing the wellness clinics. Therefore, the actual staffing costs for each of the five sites ranged from $5,499 to $25,165, for a total staffing cost of $63,652 for the RCT implementation year (see Table 4). In addition, a sensitivity analysis of potential staffing costs based on assumptions described in the methods. If a future site wanted to implement the program in two buildings, the estimated staffing costs would be $5,499 using the minimum assumptions, $31,745 using the moderate assumptions, and $57,990 using the maximum assumptions (see Table 4). Furthermore, if a future site wanted to implement the program in four buildings, the estimated staffing costs would be $5,499 using the minimum assumptions, $53,741 using the moderate assumptions, and $101,982 using the maximum assumptions.

Table 4: Program Staffing Costs in 2016 Canadian Dollars

	Total Staffing Costs as Implemented During RCT (5 Sites)	Potential Staffing Costs For A Future Site With 2 Buildings	Potential Staffing Costs For A Future Site With 4 Buildings
Additional Paramedic Staff:*			
Number of buildings implementing CP@clinic	13	2	4
Cost of additional paramedic staff per year (50 weeks, hourly salary including benefits ranged from $50.33 to $54.99 per hour)	$31,130	-----	-----
- Actual: as implemented during the trial	-----	$0	$0
- Minimum: two paramedics on modified duties	-----	$21,996	$43,992
- Moderate: one funded CP, one paramedic on modified duties	-----	$43,992	$87,984
- Maximum: two funded CPs			
Additional Supervision and Administration:			
Cost of additional supervisory and administrative staff hours per year (50 weeks)	$32,522	-----	-----
- Actual: as implemented during the trial	-----	$5,499	$5,499
- Minimum: 1 hour per week	-----	$8,249	$8,249
- Moderate: 1.5 hours per week	-----	$10,998	$10,998
- Maximum: 2 hours per week			
Other staffing (program evaluation, data repository, training development):			
Cost of other staffing ($3,000/year base cost)			
- Actual: as implemented during the trial	$0	-----	-----
- Minimum: Funded entirely from external source	-----	$0	$0
or in-kind	-----	$1,500	$1,500

- Moderate: 50/50 mixed funding model - Maximum: Funded entirely by the paramedic service	-----	$3,000	$3,000
TOTALS:			
- Actual costs during RCT (5 sites)	**$63,652**	**-----**	**-----**
- Minimum Assumption Scenarios (1 site)	-----	**$5,499**	**$5,499**
- Moderate Assumption Scenarios (1 site)	-----	**$31,745**	**$53,741**
- Maximum Assumption Scenarios (1 site)	-----	**$57,990**	**$101,982**

Notes: *Paramedic staff funded specifically for the Community Paramedicine role and not on modified duty; CP = Community Paramedic

Total program costs: Taking the direct program costs ($64,810) together with the staffing costs ($63,652), the actual cost of running the intervention in all five RCT sites for one year was $128,462. Under the different staffing assumptions, the total program costs for one community planning to implement CP@clinic in the future would be expected to range from $18,461 to $70,952 for two buildings and from $18,461 to $114,944 for four buildings.

Given that there were 1,461 apartment units in the intervention buildings and using a conservative estimate of one resident per apartment unit (more than 90% of the building residents live alone[3]), the total program cost per resident was $88. This calculation assumed that all residents had the potential to attend the program, whether they did or not, as per our other costings. In addition, the total program cost per EMS call avoided was $814.

Cost-Utility Main Analysis

The CP@clinic RCT found a gain of 0.04 QALY per intervention building resident (see Table 2). Therefore, the program cost per QALY gained of the CP@clinic intervention was $2,200 (see Table 5). This value was well below the $50,000 willingness to pay threshold commonly suggested for health intervention cost-effectiveness.

Table 5: Cost-utility analysis of CP@clinic Intervention in 2016 Canadian Dollars

QALY Gained Per Resident	0.04	
Program Cost Per Resident* (direct costs and staffing)	$88	
Base Case ICER (Program Cost per QALY)	$2200	
Sensitivity Analysis of Potential Cost Offset due to EMS Call Reduction*		
Minimum Assumption: $499/EMS call		
- Cost offset per resident	(-$54)	
- ICER (Cost per QALY)	$850	
Moderate Assumption: $1626/EMS call		
- Cost offset per resident	(-$176)	
- ICER (Cost per QALY)	(-$2,200)	(Intervention Dominant)
Maximum Assumption: $2254/EMS call		
- Cost offset per resident	(-$243)	
- ICER (Cost per QALY)	(-$3,875)	(Intervention Dominant)

Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality-Adjusted Life Year; *Reduction of 10.8 EMS calls per 100 residents

319 **Cost-Utility Sensitivity Analysis**

320 The base case cost-utility analysis reported above did not include any cost offsets. From the
321 perspective of a paramedic service, the potential cost offset due to reduced EMS calls observed
322 in the RCT (main trial results) could vary depending on the value attributed to each EMS call. In
323 the literature, it was noted that the minimum cost of an EMS call in 2017 was $499 CDN, the
324 moderate cost was $1,626 CDN, and the maximum cost was $2,254 CDN).[12] Therefore, due
325 to the reduction of 157.8 EMS calls over the intervention year, the estimated cost avoided
326 during the RCT ranged from $78,742 to $355,681. This resulted in a cost offset of $54 to $243
327 per resident (see Table 5). Under the minimum cost offset assumption, the ICER was $850, and
328 under both the moderate and maximum assumptions, the intervention was dominant (see Table
329 5).

330

331 **Potential Net Program Cost to Paramedic Services**

332 The range of potential program costs if communities were to implement the CP@clinic program
333 in the future would be expected to vary depending on their staffing model. Table 6 shows the
334 matrix of the potential *net cost,* from the perspective of the paramedic service, of implementing
335 CP@clinic in two buildings and in four buildings according to each combination of total program
336 cost and cost offset assumptions. The net potential cost ranges from -$36,259 (capacity saving)
337 to $58,838 for two buildings and from -$90.979 (capacity saving) to $90.716 for four buildings.

338

339 **Table 6: Potential net program cost for a future paramedic service implementing CP@clinic under**
340 **different assumption scenarios**

		Potential Program Costs - Two Intervention Buildings (Direct costs and staffing)		
		Minimum Assumption ($18,461)	Moderate Assumption ($44,707)	Maximum Assumption ($70,952)
Potential Cost Offsets*	Minimum Assumption ($12,114)	6,347	32,593	58,838
	Moderate Assumption ($39,474)	(-21,013)	5,233	31,478
	Maximum Assumption ($54,720)	(-36,259)	(-10,013)	16,232

341 Notes: QALY = Quality-Adjusted Life Year; *expected offset for two future buildings, based on the randomized
342 controlled trial results of 157.8 fewer calls in 13 buildings, and a value of $499/call for minimum, $1,626/call for
343 moderate, and $2,254/call for maximum cost offset assumptions

344

		Potential Program Costs - Four Intervention Buildings (Direct costs and staffing)		
		Minimum Assumption ($18,461)	Moderate Assumption ($66,703)	Maximum Assumption ($114,944)
Potential Cost Offsets*	Minimum Assumption ($24,228)	(-5,767)	42,475	90,716
	Moderate Assumption ($78,949)	(-60,488)	(-12,246)	35,995
	Maximum Assumption ($109,440)	(-90,979)	(-42,737)	5,504

Notes: QALY = Quality-Adjusted Life Year; *expected offset for four future buildings, based on the randomized controlled trial results of 157.8 fewer calls in 13 buildings, and a value of $499/call for minimum, $1,626/call for moderate, and $2,254/call for maximum cost offset assumptions

DISCUSSION

This paper presents a cost-utility analysis of the CP@clinic program with several sensitivity analyses. The incremental cost per QALY for CP@clinic is very reasonable compared to existing Canadian literature on community paramedicine interventions. The ICER of a home visit program in Renfrew County, Ontario has been described to be between $67,000 and $76,000 [8] compared to the CP@clinic ICER of $2,200. The commonly held threshold for willingness to pay for an intervention is $50,000 CDN.[13] The results highlight that through CP@clinic it is possible to not only reduce the number of EMS calls emanating from subsidized (social) housing buildings, but to improve resident health-related quality of life while doing so. This presents an opportunity for health policy to recommend this program for upscale, with vast potential benefits beyond those explored within the scope of this evaluation (e.g. hospitalizations). Considering this empirical evidence, the argument for adoption of the CP@clinic program is very strong.

Our sensitivity analyses present different scenarios that can be taken into account when planning an implementation of CP@clinic. Since the program has fixed implementation costs (e.g. laptop) that could be used for running CP@clinic in many buildings without additional investment, the net program cost for a future site is dependent on the number of buildings in which they will be implementing, as well as the staffing model used. Different assumptions of staffing needed to implement the program and also the potential cost offset have been presented since, in reality, paramedic service organizations had different local solutions for their implementation of the program. Though some implemented CP@clinic with a full staffing complement, others were able to utilize their staff who were on modified duty. Combinations of regular and modified duty staff were also abundant in reality. Some paramedic services noted that the continuity and consistency provided by having the same staff person was beneficial. However the economic savings of using modified staff present an opportunity that cannot be ignored in the practical situation of scarce funding and resources to provide healthcare.[16,17] With this in mind, we would recommend that CP@clinic could ideally be staffed by one funded CP, plus one CP on modified duties; having one consistent CP would help foster a positive relationship between the CP@clinic attendee and the paramedic,[6] and would be more cost-effective than the model using two funded CPs..

Other community paramedicine or similar programs in the literature may not be comparable as they describe substantially different scenarios and contexts. However, they do describe and help with understanding the comparative value of CP@clinic within the arena of health programming. For example, the cost per participant in a Remote Patient Monitoring (RPM) CP program in Southern Ontario was estimated at $1,134.[18] Our cost per resident of $88 is very reasonable and much lower than the cost of remote patient monitoring, which by nature is more labour intensive. If we postulate that we should account for program attendees only, the cost is slightly more at $216 per attendee, which is still much lower than that of the RPM. However, in the case of CP@clinic, the program is offered for all residents of the subsidized housing buildings therefore, we feel it is appropriate to cost it out as though everyone could attend. The RPM program has been documented to avoid up to 26% EMS calls (n=453),[18] and with their overall program cost of $737,100, the cost per EMS call avoided was $1,627. In contrast, CP@clinic has also been documented to avoid a comparable proportion of 19% of EMS calls (n=157.8 calls),[3] at a cost per call avoided of $814, demonstrating that CP@clinic has the ability to be an affordable community paramedicine program.

In this work we have potentially under-estimated the impact of the CP@clnic program on residents' health and healthcare utilization. We have not formally considered the long-term impacts of the program on the reduction of morbidity, mortality and hospital admission avoidance. This information requires careful linkage to geographical and individual information in order to be able to piece together the long-term picture and was beyond the scope of this economic evaluation. This has been planned for future analysis. Similarly, it was outside of the scope of this study to track the specific nature of the calls made pre- and post-intervention to be able to assign a specific cost to each call. Thus, sensitivity analyses based on the range of potential call values were conducted. Additionally, we have assumed a consistent program effect size for all staffing scenarios, but realistically the effect size may have been greater with more paramedic staff on hand. Future research should determine the implications of different staffing models on the scale of intervention effect.

CONCLUSION

In summary, CP@clinic not only avoided 157.8 EMS calls, but improved the quality of life of vulnerable older adults living in subsidized housing. Including the reduction in the EMS calls and their associated costs in the analysis resulted in an intervention that is both cheaper and more effective than usual care. All sensitivity analysis for cost per QALY were below commonly held willingness to pay thresholds indicating that CP@clinic represents value for money.

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Ethics Approval: This study was approved by the Hamilton Integrated Research Ethics Board (#14-210 and #14-645).

Data Sharing Statement: The data that support the findings of this study are not publicly available due to them containing information that could compromise participant privacy. De-identified, limited data will be shared by the corresponding author upon request.

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CHEERS Checklist
Items to include when reporting economic evaluations of health interventions

The **ISPOR CHEERS Task Force Report**, *Consolidated Health Economic Evaluation Reporting Standards (CHEERS)—Explanation and Elaboration: A Report of the ISPOR Health Economic Evaluations Publication Guidelines Good Reporting Practices Task Force,* provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	1-2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	30-57
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	95-106
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	110-114
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	102-106
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	102-106, 110-112, 237-239
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	122-127
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	110-122, 152-156. 256-257
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	241-245, 256-257
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	114-116, 142-145
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	110-135

	11b	*Synthesis-based estimates:* Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	N/A
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	N/A
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity cost	189-245
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	N/A
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	189
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	N/A
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	220-235, 241-244
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	259-282
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Tables 1-4, 129-135, 167-173, 287-289, 295-305, 310-320
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Table 5 323-326, 332-341
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact	

		of methodological assumptions (such as discount rate, study perspective).	332-341, 344-349
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	N/A
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Table 4 310-314
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	362-420
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	433-435
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	436

For consistency, the CHEERS Statement checklist format is based on the format of the CONSORT statement checklist

The **ISPOR CHEERS Task Force Report** provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* link or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

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BMJ Open

Cost-effectiveness analysis of a Community Paramedicine Program for low-income seniors living in subsidized housing: The Community Paramedicine at Clinic Program (CP@clinic)

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Cost-effectiveness analysis of a Community Paramedicine Program for low-income seniors living in subsidized housing: The Community Paramedicine at Clinic Program (CP@clinic)

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ABSTRACT

Objectives: To evaluate the cost-effectiveness of CP@clinic compared to usual care in seniors residing in subsidized housing.
Design: Cost-utility analysis was conducted within a large pragmatic cluster randomized controlled trial (RCT). Subsidized housing buildings, matched by socio-demographics and location (rural/urban), were allocated to intervention (CP@clinic for 1 year) or control (usual care) via computer-assisted paired randomization.
Setting: Thirty-two subsidized seniors' buildings (social housing) in Ontario.
Participants: Building residents 55 years and older.
Intervention: CP@clinic is a community paramedic-led, weekly chronic disease health promotion program held in building common areas. CP@clinic is free to residents and includes risk assessments, referrals to resources, and reports to family physicians.
Outcome measures: Changes in quality-adjusted life years (QALYs) measured with EQ-5D-3L. QALY change analysed between groups post-intervention, controlling for pre-intervention values and building pairings. Data on program costs were collected prior to inception and during implementation. Costs associated with emergency medical service (EMS) use were also estimated. An incremental cost effectiveness ratio (ICER) based on total program costs was calculated. Probabilistic sensitivity analysis using bootstrapping was performed.
Results: The RCT included 1461 residents; 146 (intervention) and 125 (control) seniors completed the EQ-5D. Differences in QALYs between groups were significant; unadjusted mean QALY gain was 0.06 (95%CI: 0.01-0.12); adjusted mean QALY gain was 0.04 (95%CI: 0.01-0.07) in the intervention group. Total program cost for implementing in five communities was CAN$128,462 and the reduction in EMS calls avoided an estimated CAN$256,583. The ICER was CAN$2,200/QALY [bootstrapped mean ICER with Fieller's 95% CI was $4645 ($2489, $10,127)] but could be even more cost effective after accounting for the EMS call reduction.
Conclusion: The CP@clinic ICER was well below the Canadian cost-utility threshold of CAN$50,000. CP@clinic scale-up across subsidized housing is feasible and could result in better health-related quality-of-life and reduced EMS use in low-income seniors.

Strengths and limitations of this study:

- the study is an economic evaluation of a community paramedicine program
- community paramedicine programs are infrequently evaluated from a health economic perspective
- this study adopts the perspective of the paramedic service that might implement such a program
- this evaluation did not include long-term implications of the program and therefore may have underestimated its economic value
- a uniform cost was applied for EMS use despite potential differences due to service or type of call, therefore slight variations in cost remain unaccounted

INTRODUCTION

Community Paramedicine (CP) is an emerging field that is actively expanding across Canada. Community paramedics are deployed in non-traditional, non-acute response settings, which can involve health promotion and disease prevention activities.[1] This new paramedicine role has already demonstrated having a positive impact on the quality of life and health of vulnerable populations,[2,3] while also reducing utilization of emergency medical services.[2,3] In addition, there are potential benefits to the health and wellbeing of paramedics who take on CP roles. [4-6] Though community paramedicine models are emerging widely, evaluation of these programs and activities is rare and those that do exist lack rigour.[1] Evaluation of CP programs should include economic evaluations in order to drive and inform policy change in health authorities. Where these economic evaluations can take account of staffing models, such as modified or non-modified/regular staff, it is even more applicable to healthcare planning.

Though some community paramedicine programs from differing contexts have been evaluated for cost-effectiveness, a recent review for Alberta Health Services concluded that the cost-effectiveness of the CP trials included in their study was not readily generalizable to other settings due to differences in program models.[7] The programs that had a cost-effectiveness evaluation constituted one involving an on-site nurse practitioner-paramedic collaboration and off-site family physician for patients over 40 years of age with chronic disease, and another with a paramedic practitioner for patients over 60 years of age. A recent study conducted in Renfrew County, Ontario, performed an economic evaluation of a home visit program model (Aging at Home) and was able to demonstrate an incremental cost per quality-adjusted life year (QALY).[8] However, no studies have evaluated the cost-effectiveness of a wellness or clinic style community model of community paramedicine.

The Community Paramedicine at clinic program (CP@clinic) has been evaluated in the format of a rigorous randomized controlled trial (RCT), in which it was found to have positive effects on the reduction of EMS calls from implementation sites, with a reduction of -0.88 calls/month/100 apartment units in Hamilton, and a reduction of -0.90 calls/month/100 apartment units in the sensitivity analysis for the whole RCT.[2,3] We sought to evaluate the cost-effectiveness of the CP@clinic program compared to usual care for low-income seniors living in subsidized (social) housing using a cost-utility analysis. The perspective of the paramedic service was chosen since it is the implementer of such community programs, and can receive funding from multiple sources, both Ministry and Public payer, depending on its geographic location. Therefore, the paramedic service perspective is the most transferrable, and they would require this type of information to determine future implementation.

METHODS

Design and Setting

This cost-utility analysis (with multiple sensitivity analyses) was conducted from the perspective of paramedic services within the context of a large pragmatic cluster RCT in 2015/2016 for which the protocol [9] and results [3] have been published elsewhere. The one-year RCT

evaluated the CP@clinic program in subsidized housing for seniors (aged 55 and older) in five communities across Ontario, Canada. The cost-utility analysis was conducted alongside the trial, using quality-of-life measures that could be translated into comparable outcomes. Ethical approval was obtained through the Hamilton Integrated Research Ethics Board (study numbers #14-210 and #14-645). Twenty-six subsidized seniors' buildings, matched by socio-demographics and location (rural and urban, Ontario), were allocated to intervention (CP@clinic for 1 year) or control (usual care) via computer-assisted paired randomization. Housing organizations provided building level information which was used in the matching process: proportion of 'older aged' residents, number of units in the building, number of 911 calls per month per 100 units (baseline), and presence of building-level wellness programming. Inclusion criteria were that each building required more than 60% of residents aged 55 years and older, more than 50 residential units, a unique postal code, and had at least one building of similar size and demographic to form a matched pair. There were no exclusion criteria.

Patient and Public Involvement

The broader RCT, through which this data was collected, was first piloted in a single location where building residents (participants) and paramedics had multiple opportunities to shape the future RCT study design and implementation, through comments on the program. Paramedics provided expert advice on the intervention locations (buildings), timing, and session length in social housing. They also advised on their opinion regarding the best method for providing immediate reports to the participants (e.g. printing on-site was not feasible) and sending reports to family doctors. In addition, paramedics informed some of the process metrics collected and disseminated in the study's regular stakeholder reports. Pilot study participants provided input on the best location within the housing building for the sessions, session timing, paramedic consistency (i.e. having the same paramedic each week), and participant resources (e.g. participant card for tracking their goals and measurements). Results were not disseminated to patients, other than each individuals' assessment summary which was provided to them after each session.

Intervention

Standardized weekly CP@clinic sessions were delivered at buildings by community paramedics. A full description of the CP@clinic program is available elsewhere.[2] Risk assessment, disease prevention and health promotion sessions were led by community paramedics, using validated tools focussing on cardiovascular, diabetes, and fall risk. Sessions were open to all building residents and one-on-one and drop-in, taking place in common areas of intervention buildings. After informed consent was taken, paramedics entered data directly into the CP@clinic database, which generated decision support advice. Attendees were counseled on specific lifestyle changes and accessible community resources or relevance Attendees were given a session card outlining their modifiable risk factors and resources that had been discussed. Session summaries were faxed to family physicians, with patient consent. Control buildings received usual care, or services that residents may access by visiting their family physician and ongoing services in their building by local community agencies.

Data Collection

All costs presented are in Canadian Dollars for the 2016 year and represent the costs to the paramedic service implementing CP@clinic (program and staffing costs).

Quality of Life:

Data were collected on quality-of-life from intervention and control building residents before (between October 2014 and December 2015) and after the program (between December 2015 and December 2016). The data collection timing reflected the staggered nature of the RCT starts dates in each site, though at least 12 months was allowed between the before and after surveying. We used the EuroQol Quality of Life Measurement Tool, EQ-5D 3L, by permission.[10] Participants, who were building residents 55 years and older, were invited to complete the survey through invitation posters that were displayed throughout the building, and flyers that were handed out to residents, describing the day and time that the research team would be present to administer the questionnaires. After obtaining informed written consent, data collection was performed by trained research assistants, on paper, due to low educational levels and poor health literacy of participants.[11] The research assistant read each question to the participant, including the answer categories and prompts, and noted the participant's responses. A consecutive sampling method was used, due to the difficulty of surveying in this vulnerable population.[11] Upon completion, the participants were provided with a local grocery gift card worth $10.

Program Costs:

In all communities that took part in the CP@clinic RCT it was found that the local housing authority routinely did not charge for space when other publicly funded or nonprofit organizations were providing health and wellness programming to residents. It is not within the mandate of regional or municipal housing organizations to provide health-related services,[12] but they recognize the value of these types of programs for residents, so they welcomed CP@clinic using the space in-kind. Direct program costs of running CP@clinic included the vehicle to transport the community paramedics between their base and each of the intervention buildings, technology-related costs (software, information technology support, database administration, and YubiKey), and session equipment (laptop, weighing scale, tape measure, blood glucose measurement items, WatchBP Office blood pressure monitoring device, and a carry bag).

Staffing Costs:

Paramedic services are responsible for all of these costs. These included salaries, materials for session implementation and technology-related costs. Where possible, costs were obtained from the source from which the service, object or goods were obtained. Detailed records were kept of all materials required for the implementation of the program. These records were validated with community paramedic supervisors. Staffing hours and salary levels were also verified with paramedic services. Paramedic salary hourly costs were obtained from paramedic

services implementing CP@clinic and where unknown, the highest salary from other services was used. The combined hourly cost of supervision and administration within the paramedic service to oversee the community paramedics was estimated at 200% of paramedic hourly salary with benefits based on information provided by the services. Paramedic vehicle and vehicle-related costs (i.e. mileage to cover maintenance and fuel) were also obtained from the paramedic services directly. Since the paramedic services implementing CP@clinic had different paramedic salary rates, staffing models (dedicated community paramedics versus paramedics on modified duty), and vehicle-related costs, the **total actual costs for all five RCT sites together were used to evaluate cost-effectiveness**. Also, in order to inform paramedic services considering implementing CP@clinic in the future, the costs for each staffing model observed during the RCT have been presented as a sensitivity analysis with three potential staffing models below. Note that staff placed on modified duties are those who are unable to do regular paramedic duties because of temporary physical/mental health conditions.

1) Model 1 (minimum): Two paramedics staffing CP@clinic, both on ‘modified’ duties, therefore not requiring additional salary costing; 1 hour per week of administrative time; and other staffing (e.g. database management) provided in-kind or funded by external sources.
2) Model 2 (moderate): Two paramedics staffing CP@clinic, but one paid as a community paramedic, and one on modified duties; 1.5 hours per week of administrative time, and the cost of other staffing split 50/50 between the paramedic service and external/in-kind funding.
3) Model 3 (maximum): Two paramedics staffing CP@clinic, both paid as community paramedics; 2 hours per week of administrative time, and the full cost of other staffing being paid for by the paramedic service.

Since the paramedic service perspective has been taken, the healthcare costs examined in this paper do not go beyond the EMS call (e.g. hospital admissions, duration of stay, specialist visits). Data on the number of EMS calls avoided were taken from the RCT results (see Table 1), which found that the intervention buildings had 10.8 fewer calls per 100 apartment units post-intervention, compared to control buildings. The costs (in Canadian dollars) estimated for potential EMS call offset were obtained from Canadian literature in 2017 where we found $499/call to be a minimum cost, $1626/call to be a moderate cost, and $2254/call to be the maximum cost.[13] Inflation according to the Consumer Price Index for Healthcare, [14] was not required since the one-year intervention was in 2015/2016. The base case cost-utility analysis was conducted without any cost offset from the avoided EMS calls and then a sensitivity analysis was conducted using a range of potential cost offsets depending on the value assigned to the average EMS call.

Outcomes

The main outcome was QALY gained (change from baseline) in the intervention buildings compared to the control buildings, over the 1 year intervention period. This was used because of the difference in the utilities of participants at baseline.[15] The cost-effectiveness outcomes were analyzed and presented as incremental cost-effectiveness ratios (ICERs) of the

intervention (CP@clinic) versus control (usual care). Cost-effectiveness, in the form of a cost-utility analysis, was evaluated based on the cost of implementing and maintaining the CP program and QALYs as the measure of effectiveness; sensitivity analyses also included EMS calls avoided in the ICER calculation. ICERs were presented where appropriate (when the intervention was not dominant/dominated). The time horizon of the analysis was 12 months, therefore discounting techniques were not used.

Analysis

The value of the total number of QALYs was calculated by computing the mean QALYs change from baseline during the program period (1-year). The raw EQ-5D-3L survey responses were treated as five-digit vectors (e.g. 13415) and transformed into index scores using the previously validated Canadian EQ5D-3L value sets.[16] For each individual, the difference in the pre-intervention and post-intervention index scores was calculated and multiplied by 1 year to get the QALY gained over the 1 year intervention. These values were then adjusted for baseline differences using regression. Missing QALY values were calculated using multiple imputation techniques (iterative Markov chain Monte Carlo method). Age, education, presence of chronic diseases (hypertension, heart disease, diabetes, high cholesterol, previous stroke), gender, living arrangement (living alone, marital status), baseline EQ5D measures (by individual domains), and baseline utility were used to impute for the missing utility values.

Cost of the program per resident was calculated by dividing the total program cost (summation of all program expenses) divided by the number of units in the intervention buildings. This provided a conservative estimate of the cost per resident since over 90% of units only had one resident [3]; as the number of residents per unit increases, the cost per resident decreases, therefore assuming one resident per unit is the most conservative approach to estimating the cost per resident with fluctuating building resident numbers. The incremental cost per QALY was the ratio of the difference in cost of the CP@clinic per building resident compared to the control group ($0 was assumed because there was no program added) divided by the difference in mean QALY gained in the intervention group compared to the control group. In addition, we conducted Bootstrap Probabilistic Sensitivity Analysis (PSA) using 1000 bootstrap samples of the complete case dataset of post-intervention utility (controlling for baseline values using regression) to determine the uncertainty around the ICER. We created a cost-effectiveness acceptability (CEA) curve based on the PSA analysis to show the probability of the program being cost-effective based on the willingness to pay. Also, potential net program costs were calculated based on the range of costs that could be assigned to each EMS call avoided.

We used the ICER threshold of $50,000 CDN per QALY, which has been suggested as a conservative lower boundary for a willingness to pay threshold.[17]

The program cost per EMS call avoided was the ratio of total program cost over the total number of EMS calls avoided. Finally, the potential net cost for a future site wanting to implement the CP@clinic program in two buildings and in four buildings was calculated for each of the three different staff costing scenarios and each of the three cost-offset scenarios.

RESULTS

Main Trial Results: As published previously, the CP@clinic RCT demonstrated significantly reduced EMS calls after 1 year of implementation when adjusted for the study design (i.e. building pairing) and baseline calls.[3] Comparing intervention and control buildings, there was an adjusted mean monthly difference of -0.90 calls per 100 apartment units per month (95%CI = -1.54 to -0.26), which translates to an estimated 10.8 fewer EMS calls per 100 apartment units per year (see Table 1). Since the intervention buildings had 1461 units, it can be estimated that 157.8 EMS calls were avoided during the intervention period.

Table 1: Difference in emergency medical service call rates for intervention and control buildings (main trial results)

	Intervention Buildings Mean (SD)	Control Buildings Mean (SD)	Mean Difference (95% CI)
Baseline: Unadjusted monthly EMS calls per 100 units	4.13 (2.79)	4.60 (2.80)	-0.47 (-1.12 to 0.18)
After 1 year: Unadjusted monthly EMS calls per 100 units	3.67 (2.75)	4.79 (2.93)	-1.12 (-1.78 to 0.46)
Unadjusted: Monthly Mean Difference	-0.47 (3.83)	0.19 (3.57)	-0.65 (-1.51 to 0.20)
Adjusted:** Monthly Mean Difference	------	-----	-0.90 (-1.54 to -0.26)*
Expected annual decrease in 911 calls: 10.8 calls / 100 apartment units / year			

Notes: EMS = Emergency Medical Service; n = 26 buildings (13 pairs of intervention and control buildings);
* p < 0.006; ** adjusted for building pairing and pre-intervention baseline

In addition, the CP@clinic intervention had a positive effect on resident health-related quality of life in the intervention buildings, compared to the control buildings (see Table 2); this is a building-level result that includes individuals from the intervention buildings, regardless of whether or not they opted to attend the program sessions. A total of 358 residents from intervention buildings and 320 residents from control buildings participated in the survey prior to the start of the intervention (pre-intervention). At 1 year post-intervention, 196 residents from the intervention buildings and 125 residents from the control buildings completed the survey again due to some having moved, died or being lost to follow up (see Figure 1). Resident demographics per site are shown in Supplementary Table 1. Multiple imputation was used to account for the missing data in the sensitivity analysis.

Table 2: Difference in QALY for intervention and control buildings

	Intervention Building Residents versus Control Building Residents		
	Intervention Mean (SD)	**Control Mean (SD)**	**Mean Difference (95% CI)**
MAIN TRIAL RESULTS With multiple imputation (intention-to-treat)	n=358	n=320	
Unadjusted QALY (change from baseline): Mean difference in EQ-5D index score over 1 year	0.10 (0.39)	0.04 (0.38)	0.06* (0.01, 0.12)
Adjusted[a] QALY (change from baseline): Mean difference in EQ-5D index score over 1 year, regression adjusted for baseline score	0.05 (0.19)	0.01 (0.23)	0.04* (0.01, 0.07)
BOOTSTRAPPING Without multiple imputation (complete case)	n=196	n=125	
Adjusted[a] QALY: Post-intervention EQ-5D index score, regression adjusted for baseline score	0.752 (0.17)	0.703 (0.17)	0.05* (0.01, 0.09)
Bootstrap Probabilistic Sensitivity Analysis: Adjusted QALY (post-intervention EQ-5D index score, regression adjusted for baseline score)	0.744 (0.07)	0.715 (0.08)	0.03* (0.01, 0.04)

Notes: QALY = Quality-Adjusted Life Year; *$p < 0.05$; [a]Intervention and Control EQ-5D index scores were found to be significantly different at baseline, despite randomization, therefore baseline differences were accounted for by adjustment using regression

Over the course of the 1-year intervention, there was an unadjusted 0.06 QALY change (from baseline) per person (95% CI, 0.01 to 0.12) in favour of the intervention buildings. When adjusting for baseline differences in the EQ-5D index score between the intervention and control buildings using regression, there was a significant adjusted mean 0.04 QALY change per person (95% CI, 0.01 to 0.07).

Program Costs

Direct costs: The direct program cost of CP@clinic per community was $12,962, and the overall direct program cost for the five communities in the RCT was $64,810, excluding staffing. Please see Table 3 for the list of costs per item and source.

Table 3: Direct Program Costs in Canadian Dollars (excluding staffing)

Item	Source	Cost per site ($ CAD in 2016)
Space	Housing authority of each community	In-kind
Vehicle incl. fuel and maintenance	Paramedic service of each community	10,000
Information technology supports and overheads	McMaster University, DFM IT	500
Database software	McMaster University, DFM IT	235
YubiKey	McMaster University, DFM IT	53
Printing and materials (e.g. posters, flyers, BP record card)	McMaster University Media Services	253
Session Equipment:		
Laptop	McMaster University, DFM IT	726
Weighing scale	Medical supply vendor	240
Tape measure	Medical supply vendor	5
BP machine (WatchBP Office)	Medical supply vendor	750
Glucometer, lancets, swabs, bandages	Paramedic service of each community	150
Carry Bag	Office supply vendor	50
	Direct program costs per community:	12,962
	Total direct program costs for all five RCT study sites:	**64,810**

Notes: BP = Blood pressure; DFM IT = Department of Family Medicine Information Technology; RCT = Randomized Controlled Trial

Staffing costs**:** Each site had different staffing arrangements during the RCT, such as rate of pay, number of buildings receiving the intervention, and number of paramedics on modified duties staffing the wellness clinics (see Supplementary Table 2). Therefore, the actual staffing costs for each of the five sites ranged from $5,499 to $25,165, for a total staffing cost of $63,652 for the RCT implementation year (see Table 4). In addition, a sensitivity analysis of potential staffing costs based on assumptions described in the methods. If a future site wanted to implement the program in two buildings, the estimated staffing costs would be $5,499 using the minimum assumptions, $31,745 using the moderate assumptions, and $57,990 using the maximum assumptions (see Table 4). Furthermore, if a future site wanted to implement the program in four buildings, the estimated staffing costs would be $5,499 using the minimum assumptions, $53,741 using the moderate assumptions, and $101,982 using the maximum assumptions.

Table 4: Program Staffing Costs in 2016 Canadian Dollars

	Total Staffing Costs as Implemented During RCT (5 Sites)	Potential Staffing Costs For A Future Site With 2 Buildings	Potential Staffing Costs For A Future Site With 4 Buildings
Additional Paramedic Staff:*			
Number of buildings implementing CP@clinic	13	2	4
Cost of additional paramedic staff per year (50 weeks, hourly salary including benefits ranged from $50.33 to $54.99 per hour)	$31,130	-----	-----
- Actual: as implemented during the trial	-----	$0	$0
- Minimum: two paramedics on modified duties	-----	$21,996	$43,992
- Moderate: one funded CP, one paramedic on modified duties	-----	$43,992	$87,984
- Maximum: two funded CPs			
Additional Supervision and Administration:			
Cost of additional supervisory and administrative staff hours per year (50 weeks)	$32,522	-----	-----
- Actual: as implemented during the trial	-----	$5,499	$5,499
- Minimum: 1 hour per week	-----	$8,249	$8,249
- Moderate: 1.5 hours per week	-----	$10,998	$10,998
- Maximum: 2 hours per week			
Other staffing (program evaluation, data repository, training development):			
Cost of other staffing ($3,000/year base cost)			
- Actual: as implemented during the trial	$0	-----	-----
- Minimum: Funded entirely from external source or in-	-----	$0	$0
kind	-----	$1,500	$1,500
- Moderate: 50/50 mixed funding model	-----	$3,000	$3,000
- Maximum: Funded entirely by the paramedic service			
TOTALS:			
- **Actual costs during RCT (5 sites)**	**$63,652**	-----	-----
- **Minimum Assumption Scenarios (1 site)**	-----	**$5,499**	**$5,499**
- **Moderate Assumption Scenarios (1 site)**	-----	**$31,745**	**$53,741**
- **Maximum Assumption Scenarios (1 site)**	-----	**$57,990**	**$101,982**

Notes: *Paramedic staff funded specifically for the Community Paramedicine role and not on modified duty; CP = Community Paramedic

Total program costs: Taking the direct program costs ($64,810) together with the staffing costs ($63,652), the actual cost of running the intervention in all five RCT sites for one year was $128,462. Under the different staffing assumptions, the total program costs for one community planning to implement CP@clinic in the future would be expected to range from $18,461 to $70,952 for two buildings and from $18,461 to $114,944 for four buildings.

Given that there were 1,461 apartment units in the intervention buildings and using a conservative estimate of one resident per apartment unit (more than 90% of the building residents live alone[3]), the total program cost per resident was $88 for this RCT. For each site, the program cost per resident ranged from $35 to $292. This calculation assumed that all residents had the potential to attend the program, whether they did or not, as per our other costings. In addition, the total program cost per EMS call avoided was $814.

Cost-Utility Main Analysis

The CP@clinic RCT found a gain of 0.04 QALY per intervention building resident (see Table 2). Therefore, the program cost per QALY gained of the CP@clinic intervention was $2,200 (see Table 5). This value was well below the $50,000 willingness to pay threshold commonly suggested for health intervention cost-effectiveness.

Table 5: Cost-utility analysis of CP@clinic Intervention in 2016 Canadian Dollars

QALY Change Per Resident	0.04	
Program Cost Per Resident for full RCT (direct costs and staffing of $128,462 for 1461 units)	$88	
Base Case ICER (Program Cost per QALY)	$2200	
Probabilistic Sensitivity Analysis using Bootstrapping		
QALY Change Per Resident (95% Confidence Interval)	0.03 (0.01, 0.05)	
Program Cost Per Resident by Site	$35 - 292	
Mean ICER (Fieller's 95% Confidence Interval)	$4645 ($2489, $10,127)	
Analysis including Potential Cost Offset due to EMS Call Reduction*		
Minimum Assumption: $499/EMS call		
- Cost offset per resident	(-$54)	
- ICER (Cost per QALY)	$850	
Moderate Assumption: $1626/EMS call		
- Cost offset per resident	(-$176)	
- ICER (Cost per QALY)	(-$2,200)	(Intervention Dominant)
Maximum Assumption: $2254/EMS call		
- Cost offset per resident	(-$243)	
- ICER (Cost per QALY)	(-$3,875)	(Intervention Dominant)

Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality-Adjusted Life Year; *Reduction of 10.8 EMS calls per 100 residents

Probabilistic Sensitivity Analysis using Bootstrapping

After the bootstrapping analysis was performed, the CP@clinic RCT found a QALY gain of 0.03 per intervention building resident (see Table 2). The mean ICER with Fieller's 95% CI was $4645 ($2489, $10,127). The CEA curve is presented in Figure 2 with a willingness-to-pay threshold of $50,000 demonstrating that 100% acceptability was achieved well below willingness-to-pay of $15,000.

Cost-Utility Analysis with Additional Cost Offsets

The base case cost-utility analysis reported above did not include any cost offsets. From the perspective of a paramedic service, the potential cost offset due to reduced EMS calls observed in the RCT (main trial results) could vary depending on the value attributed to each EMS call. In the literature, it was noted that the minimum cost of an EMS call in 2017 was $499 CDN, the moderate cost was $1,626 CDN, and the maximum cost was $2,254 CDN).[13] Therefore, due to the reduction of 157.8 EMS calls over the intervention year, the estimated cost avoided during the RCT ranged from $78,742 to $355,681. This resulted in a cost offset of $54 to $243 per resident (see Table 5). Under the minimum cost offset assumption, the ICER was $850, and under both the moderate and maximum assumptions, the intervention was dominant (see Table 5).

Potential Net Program Cost to Paramedic Services

The range of potential program costs if communities were to implement the CP@clinic program in the future would be expected to vary depending on their staffing model. Table 6 shows the matrix of the potential *net cost,* from the perspective of the paramedic service, of implementing CP@clinic in two buildings and in four buildings according to each combination of total program cost and cost offset assumptions. The net potential cost ranges from -$36,259 (capacity saving) to $58,838 for two buildings and from -$90.979 (capacity saving) to $90.716 for four buildings.

Table 6: Potential net program cost for a future paramedic service implementing CP@clinic under different assumption scenarios

		Potential Program Costs - Two Intervention Buildings (Direct costs and staffing)		
		Minimum Assumption ($18,461)	Moderate Assumption ($44,707)	Maximum Assumption ($70,952)
Potential Cost Offsets*	Minimum Assumption ($12,114)	6,347	32,593	58,838
	Moderate Assumption ($39,474)	(-21,013)	5,233	31,478
	Maximum Assumption ($54,720)	(-36,259)	(-10,013)	16,232

Notes: QALY = Quality-Adjusted Life Year; *expected offset for two future buildings, based on the randomized controlled trial results of 157.8 fewer calls in 13 buildings, and a value of $499/call for minimum, $1,626/call for moderate, and $2,254/call for maximum cost offset assumptions

		Potential Program Costs - Four Intervention Buildings (Direct costs and staffing)		
		Minimum Assumption ($18,461)	Moderate Assumption ($66,703)	Maximum Assumption ($114,944)
Potential Cost Offsets*	Minimum Assumption ($24,228)	(-5,767)	42,475	90,716
	Moderate Assumption ($78,949)	(-60,488)	(-12,246)	35,995
	Maximum Assumption ($109,440)	(-90,979)	(-42,737)	5,504

Notes: QALY = Quality-Adjusted Life Year; *expected offset for four future buildings, based on the randomized controlled trial results of 157.8 fewer calls in 13 buildings, and a value of $499/call for minimum, $1,626/call for moderate, and $2,254/call for maximum cost offset assumptions

DISCUSSION

This paper presents a cost-utility analysis of the CP@clinic program with several sensitivity analyses. The incremental cost per QALY for CP@clinic is very reasonable compared to existing Canadian literature on community paramedicine interventions. The ICER of a home visit program in Renfrew County, Ontario has been described to be between $67,000 and $76,000 [8] compared to the CP@clinic ICER of $2,200. The commonly held threshold for willingness to pay for an intervention is $50,000 CDN.[17] The results highlight that through CP@clinic it is possible to not only reduce the number of EMS calls emanating from subsidized (social) housing buildings, but to improve resident health-related quality of life while doing so. This presents an opportunity for health policy to recommend this program for upscale, with vast potential benefits beyond those explored within the scope of this evaluation (e.g. hospitalizations). Considering this empirical evidence, the argument for adoption of the CP@clinic program is very strong.

Our sensitivity analyses present different scenarios that can be taken into account when planning an implementation of CP@clinic. Since the program has fixed implementation costs (e.g. laptop) that could be used for running CP@clinic in many buildings without additional investment, the net program cost for a future site is dependent on the number of buildings in which they will be implementing, as well as the staffing model used. Different assumptions of staffing needed to implement the program and also the potential cost offset have been presented since, in reality, paramedic service organizations had different local solutions for their implementation of the program. Though some implemented CP@clinic with a full staffing complement, others were able to utilize their staff who were on modified duty. Combinations of regular and modified duty staff were also abundant in reality. Some paramedic services noted that the continuity and consistency provided by having the same staff person was beneficial. However the economic savings of using modified staff present an opportunity that cannot be ignored in the practical situation of scarce funding and resources to provide healthcare.[18,19] With this in mind, we would recommend that CP@clinic could ideally be staffed by one funded CP, plus one CP on modified duties; having one consistent CP would help foster a positive relationship between the CP@clinic attendee and the paramedic,[6] and would be more cost-effective than the model using two funded CPs.

Other community paramedicine or similar programs in the literature may not be comparable as they describe substantially different scenarios and contexts. However, they do describe and help with understanding the comparative value of CP@clinic within the arena of health programming. For example, the cost per participant in a Remote Patient Monitoring (RPM) CP program in Southern Ontario was estimated at $1,134.[20] Our cost per resident of $88 is very reasonable and much lower than the cost of remote patient monitoring, which by nature is more labour intensive. If we postulate that we should account for program attendees only, the cost is slightly more at $216 per attendee, which is still much lower than that of the RPM. However, in the case of CP@clinic, the program is offered for all residents of the subsidized housing buildings therefore, we feel it is appropriate to cost it out as though everyone could attend. The RPM program has been documented to avoid up to 26% EMS calls (n=453),[20] and with their overall program cost of $737,100, the cost per EMS call avoided was $1,627. In contrast, CP@clinic has also been documented to avoid a comparable proportion of 19% of EMS calls (n=157.8 calls),[3] at a cost per call avoided of $814, demonstrating that CP@clinic has the ability to be an affordable community paramedicine program.

One of the limitations of this work is that we were unable to account for all loss to follow up through death and moving of residents, due to information constraints. We have potentially under-estimated the impact of the CP@clnic program on residents' health and healthcare utilization. We have not formally considered the long-term impacts of the program on the reduction of morbidity, mortality and hospital admission avoidance. This information requires careful linkage to geographical and individual information in order to be able to piece together the long-term picture and was beyond the scope of this economic evaluation. This has been planned for future analysis. Similarly, it was outside of the scope of this study to track the specific nature of the calls made pre- and post-intervention to be able to assign a specific cost to each call. Thus, sensitivity analyses based on the range of potential call values were conducted. Additionally, we have assumed a consistent program effect size for all staffing scenarios, but realistically the effect size may have been greater with more paramedic staff on hand. Future research should determine the implications of different staffing models on the scale of intervention effect. We have also only considered the perspective of the paramedic service since in Ontario they determine how to allocate staff and resource funding to extra programs. The perspective of society or other payers could be considered in future work.

CONCLUSION

In summary, CP@clinic not only avoided 157.8 EMS calls, but improved the quality of life of vulnerable older adults living in subsidized housing. Including the reduction in the EMS calls and their associated costs in the analysis resulted in an intervention that is both cheaper and more effective than usual care. All sensitivity analysis for cost per QALY were below commonly held willingness to pay thresholds indicating that CP@clinic represents value for money.

Author Contributions: GA, RA, MP, and FM were involved in study conceptualization and implementation. RA, GA and MP analyzed and interpreted the data, and DO'R and LT provided guidance in the analysis planning and interpretation. All authors were involved in preparing the paper and approved the final manuscript.

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Conflict of Interest: The authors report no conflict of interest.

Ethics Approval: This study was approved by the Hamilton Integrated Research Ethics Board (#14-210 and #14-645).

Data Sharing Statement: The data that support the findings of this study are not publicly available due to them containing information that could compromise participant privacy. De-identified, limited data will be shared by the corresponding author upon request.

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Figure 1. CP@clinic study design and data collection flow diagram

Figure 2. Cost-effectiveness acceptability curve of the CP@clinic program

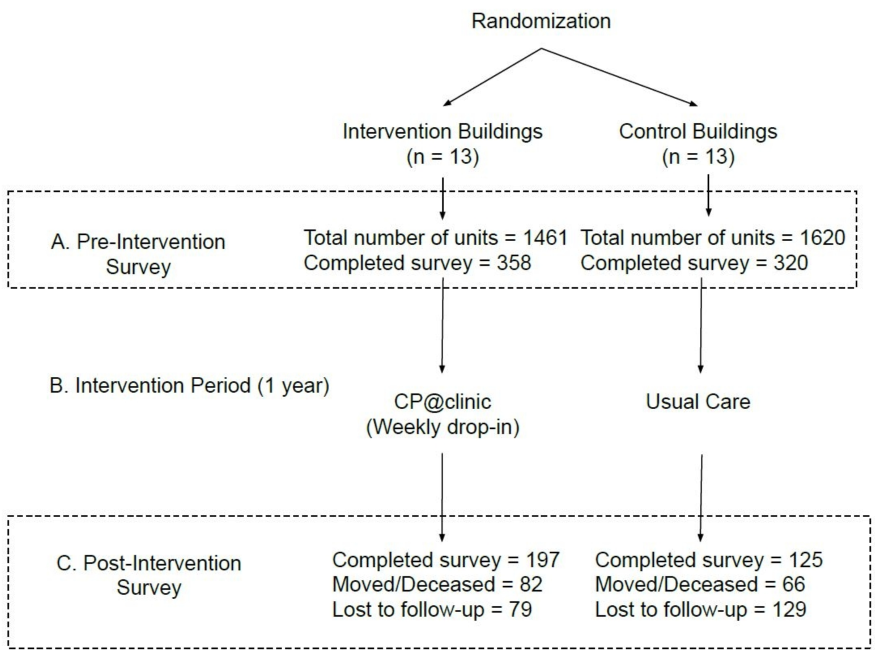

Figure 1: CP@clinic study design and data collection flow diagram

104x75mm (300 x 300 DPI)

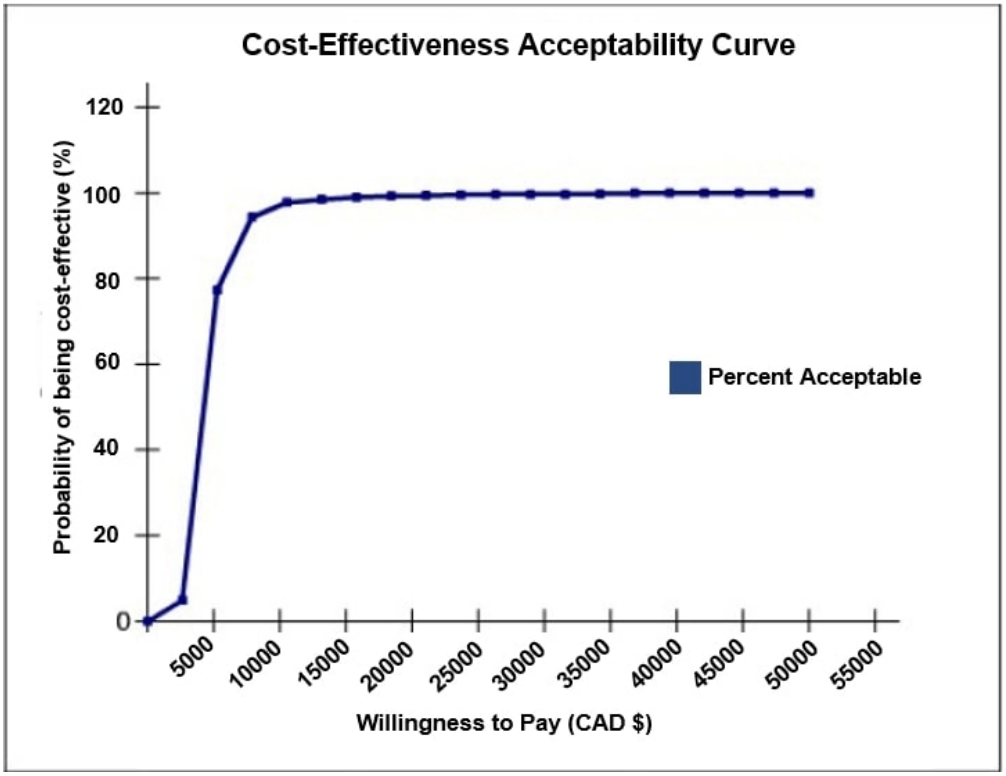

Figure 2: Cost-effectiveness acceptability curve

61x47mm (300 x 300 DPI)

Supplemental Table 1: Individual-level characteristics for intervention and control buildings at baseline

Descriptive Variables	**Intervention building n=358** **n (%)**	**Control building n=320** **n (%)**
Age years: mean (SD)	73.90 (9.05)	70.44 (7.94)
Female	286 (79.9)	229 (71.6)
Lives alone	322 (90.70)	287 (89.97)
Education		
Some High School or lower	160 (45.1)	146 (45.8)
High School Diploma	83 (23.4)	75 (23.5)
Some College/University or Higher	56 (15.8)	50 (15.7)
College or University	56 (15.8)	48 (15.0)
Poor Health Literacy[a]	80 (84.2)	84 (81.6)
With Chronic Diseases		
Heart Problems	111 (31.1)	80 (25.0)
Hypertension	192 (53.6)	177 (55.3)
High Cholesterol	135 (37.7)	119 (37.2)
Stroke	43 (12.0)	39 (12.2)
Diabetes	96 (26.8)	90 (28.1)
Risk Factors		
Low Physical Activity	148 (41.9)	166 (51.9)
Low Fruits and Vegetable intake	123 (34.6)	106 (33.2)
High Alcohol Intake	5 (1.4)	11 (3.4)
Smoker	87 (24.5)	122 (38.4)
High BMI	247 (69.6)	221 (69.0)
CANRISK[b]		
Moderate	104 (39.8)	98 (42.6)
High	151 (57.9)	123 (53.5)
Health Status and Quality-of-Life		
Reported Poor to Fair health	135 (38.0)	139 (43.5)
With mobility problems	218 (61.4)	192 (60.0)
With self-care problems	83 (23.4)	59 (18.4)
With problems doing usual activities	166 (46.8)	133 (41.6)
With pain/discomfort	249 (70.1)	239 (74.9)
With anxiety/depression	176 (48.5)	154 (48.1)
Has a Family Doctor	327 (91.3)	298 (93.1)

Notes: [a]For the health literacy assessment n= 89; for intervention 143 for control in Hamilton site only; [b]Only for participant not previously diagnosed with Diabetes

Supplemental Table 2: Actual Program Staffing Costs by Site in Canadian Dollars

	Site #1 4 buildings	Site #2 2 buildings	Site #3 1 building	Site #4 2 buildings	Site #5 4 buildings	All 5 RCT Sites 13 buildings
Number of apartment units:	615	181	101	146	418	
Additional Paramedic Staff:*						
Cost per hour of paramedic staff time, including benefits	$54.95	$50.33	$54.99	$54.99	$54.99	
Hours of <u>additional</u> paramedic staff per year (50 weeks)	0	400	200	0	0	
Subtotal: Paramedic staffing for one year	**$0.00**	**$20,132.00**	**$10,998.00**	**$0.00**	**$0.00**	**$31,130.00**
Additional Supervision and Administration:						
Cost per hour of combined supervision and administrative staff time, including benefits	$109.90	$100.66	$109.98	$109.98	$109.98	
Hours of <u>additional</u> supervisory and administrative staff hours per year (50 weeks)	75	50	50	50	75	
Subtotal: Supervisor and administration for one year	**$8,242.50**	**$5,033.00**	**$5,499.00**	**$5,499.00**	**$8,248.50**	**$32,522.00**
Other staffing (program evaluation, data repository, training development):						
Cost per year for other staff	$3,000.00	$3,000.00	$3,000.00	$3,000.00	$3,000.00	
Percentage of other staffing funded by the paramedic service	0	0	0	0	0	
Subtotal: Other staffing for one year	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
TOTALS:	**$8,242.50**	**$25,165.00**	**$16,497.00**	**$5,499.00**	**$8,242.50**	**$63,652.00**

Notes: *Paramedic staff funded specifically for the Community Paramedicine role and not assigned to modified duties; CP = Community Paramedic

CHEERS Checklist
Items to include when reporting economic evaluations of health interventions

The **ISPOR CHEERS Task Force Report**, *Consolidated Health Economic Evaluation Reporting Standards (CHEERS)—Explanation and Elaboration: A Report of the ISPOR Health Economic Evaluations Publication Guidelines Good Reporting Practices Task Force,* provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	1-2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	30-57
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	95-106
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	110-114
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	102-106
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	102-106, 110-112, 237-239
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	122-127
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	110-122, 152-156. 256-257
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	241-245, 256-257
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	114-116, 142-145
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	110-135

	11b	*Synthesis-based estimates:* Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	N/A
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	N/A
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity cost	189-245
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	N/A
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	189
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	N/A
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	220-235, 241-244
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	259-282
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Tables 1-4, 129-135, 167-173, 287-289, 295-305, 310-320
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Table 5 323-326, 332-341
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact	

		of methodological assumptions (such as discount rate, study perspective).	332-341, 344-349
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	N/A
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Table 4 310-314
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	362-420
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	433-435
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	436

For consistency, the CHEERS Statement checklist format is based on the format of the CONSORT statement checklist

The **ISPOR CHEERS Task Force Report** provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* link or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

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Cost-effectiveness analysis of a Community Paramedicine Program for low-income seniors living in subsidized housing: The Community Paramedicine at Clinic Program (CP@clinic)

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Cost-effectiveness analysis of a Community Paramedicine Program for low-income seniors living in subsidized housing: The Community Paramedicine at Clinic Program (CP@clinic)

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ABSTRACT

Objectives: To evaluate the cost-effectiveness of CP@clinic compared to usual care in seniors residing in subsidized housing.
Design: A cost-utility analysis was conducted within a large pragmatic cluster randomized controlled trial (RCT). Subsidized housing buildings were matched by socio-demographics and location (rural/urban), and allocated to intervention (CP@clinic for 1 year) or control (usual care) via computer-assisted paired randomization.
Setting: Thirty-two subsidized seniors' housing buildings in Ontario.
Participants: Building residents 55 years and older.
Intervention: CP@clinic is a weekly community paramedic-led, chronic disease prevention and health promotion program in the building common areas. CP@clinic is free to residents and includes risk assessments, referrals to resources, and reports back to family physicians.
Outcome measures: Quality-adjusted life years (QALYs) gained, measured with EQ-5D-3L. QALY gained were analysed between the groups at post-intervention, controlling for pre-intervention values and building pairings. Program cost data were collected before and during implementation. Costs associated with emergency medical service (EMS) use were also estimated. An incremental cost effectiveness ratio (ICER) based on incremental costs and health outcomes between the groups was calculated. Probabilistic sensitivity analysis using bootstrapping was performed.
Results: The RCT included 1461 residents; 146 and 125 seniors completed the EQ-5D-3L in intervention and control buildings, respectively. There was a significant adjusted mean QALY gain of 0.04 (95%CI:0.00-0.08) for the intervention group. Total program cost for implementing in five communities was CAN$128,462 and the reduction in EMS calls avoided an estimated CAN$256,583. The ICER was CAN$2,200/QALY [bootstrapped mean ICER with Fieller's 95% CI was $4645 ($2489, $10,127)] but could be even more cost effective after accounting for the EMS call reduction.
Conclusion: The CP@clinic ICER was well below the commonly used Canadian cost-utility threshold of CAN$50,000. CP@clinic scale-up across subsidized housing is feasible and could result in better health-related quality-of-life and reduced EMS use in low-income seniors.

Strengths and limitations of this study:

- the study is an economic evaluation of a community paramedicine program
- community paramedicine programs are infrequently evaluated from a health economic perspective
- this study adopts the perspective of the paramedic service that might implement such a program
- this evaluation did not include long-term implications of the program and therefore may have underestimated its economic value
- a uniform cost was applied for EMS use despite potential differences due to service or type of call, therefore slight variations in cost remain unaccounted

INTRODUCTION

Community Paramedicine (CP) is an emerging field that is actively expanding across Canada. Community paramedics are deployed in non-traditional, non-acute response settings, which can involve health promotion and disease prevention activities.[1] This new paramedicine role has already demonstrated having a positive impact on the quality of life and health of vulnerable populations,[2,3] while also reducing utilization of emergency medical services.[2,3] In addition, there are potential benefits to the health and wellbeing of paramedics who take on CP roles. [4-6] Though community paramedicine models are emerging widely, evaluation of these programs and activities is rare and those that do exist lack rigour.[1] Evaluation of CP programs should include economic evaluations in order to drive and inform policy change in health authorities. Where these economic evaluations can take account of staffing models, such as modified or non-modified/regular staff, it is even more applicable to healthcare planning.

Though some community paramedicine programs from differing contexts have been evaluated for cost-effectiveness, a recent review for Alberta Health Services concluded that the cost-effectiveness of the CP trials included in their study was not readily generalizable to other settings due to differences in program models.[7] The programs that had a cost-effectiveness evaluation constituted one involving an on-site nurse practitioner-paramedic collaboration and off-site family physician for patients over 40 years of age with chronic disease, and another with a paramedic practitioner for patients over 60 years of age. A recent study conducted in Renfrew County, Ontario, performed an economic evaluation of a home visit program model (Aging at Home) and was able to demonstrate an incremental cost per quality-adjusted life year (QALY).[8] However, no studies have evaluated the cost-effectiveness of a wellness or clinic style community model of community paramedicine.

The Community Paramedicine at clinic program (CP@clinic) has been evaluated in the format of a rigorous randomized controlled trial (RCT), in which the sensitivity analysis found CP@clinic to have positive effects on the reduction of EMS calls from implementation sites, with a reduction of -0.88 calls/month/100 apartment units in Hamilton, and a reduction of -0.90 calls/month/100 apartment units.[2,3] We sought to evaluate the cost-effectiveness of the CP@clinic program compared to usual care for low-income seniors living in subsidized (social) housing using a cost-utility analysis. The perspective of the paramedic service was chosen since it is the implementer of such community programs, and can receive funding from multiple sources, both Ministry and Public payer, depending on its geographic location. Therefore, the paramedic service perspective is the most transferrable, and they would require this type of information to determine future implementation.

METHODS

Design and Setting

This cost-utility analysis (with multiple sensitivity analyses) was conducted from the perspective of paramedic services within the context of a large pragmatic cluster RCT in 2015/2016 for which the protocol [9] and results [3] have been published elsewhere. The one-year RCT

evaluated the CP@clinic program in subsidized housing for seniors (aged 55 and older) in five communities across Ontario, Canada. The cost-utility analysis was conducted alongside the trial, using quality-of-life measures that could be translated into comparable outcomes. Ethical approval was obtained through the Hamilton Integrated Research Ethics Board (study numbers #14-210 and #14-645). Twenty-six subsidized seniors' buildings, matched by socio-demographics and location (rural and urban, Ontario), were allocated to intervention (CP@clinic for 1 year) or control (usual care) via computer-assisted paired randomization. Housing organizations provided building level information which was used in the matching process: proportion of 'older aged' residents, number of units in the building, number of 911 calls per month per 100 units (baseline), and presence of building-level wellness programming. Inclusion criteria were that each building required more than 60% of residents aged 55 years and older, more than 50 residential units, a unique postal code, and had at least one building of similar size and demographic to form a matched pair. There were no exclusion criteria.

Patient and Public Involvement

The broader RCT, through which this data was collected, was first piloted in a single location where building residents (participants) and paramedics had multiple opportunities to shape the future RCT study design and implementation, through comments on the program. Paramedics provided expert advice on the intervention locations (buildings), timing, and session length in social housing. They also advised on their opinion regarding the best method for providing immediate reports to the participants (e.g. printing on-site was not feasible) and sending reports to family doctors. In addition, paramedics informed some of the process metrics collected and disseminated in the study's regular stakeholder reports. Pilot study participants provided input on the best location within the housing building for the sessions, session timing, paramedic consistency (i.e. having the same paramedic each week), and participant resources (e.g. participant card for tracking their goals and measurements). Results were not disseminated to patients, other than each individuals' assessment summary which was provided to them after each session.

Intervention

Standardized weekly CP@clinic sessions were delivered at buildings by community paramedics. A full description of the CP@clinic program is available elsewhere.[2] Risk assessment, disease prevention and health promotion sessions were led by community paramedics, using validated tools focussing on cardiovascular, diabetes, and fall risk. Sessions were open to all building residents and one-on-one and drop-in, taking place in common areas of intervention buildings. After informed consent was taken, paramedics entered data directly into the CP@clinic database, which generated decision support advice. Attendees were counseled on specific lifestyle changes and accessible community resources or relevance Attendees were given a session card outlining their modifiable risk factors and resources that had been discussed. Session summaries were faxed to family physicians, with patient consent. Control buildings received usual care, or services that residents may access by visiting their family physician and ongoing services in their building by local community agencies.

Data Collection

All costs presented are in Canadian Dollars for the 2016 year and represent the costs to the paramedic service implementing CP@clinic (program and staffing costs).

Quality of Life:

Data were collected on quality-of-life from intervention and control building residents before (between October 2014 and December 2015) and after the program (between December 2015 and December 2016). The data collection timing reflected the staggered nature of the RCT starts dates in each site, though at least 12 months was allowed between the before and after surveying. We used the EuroQol Quality of Life Measurement Tool, EQ-5D 3L, by permission.[10] Participants, who were building residents 55 years and older, were invited to complete the survey through invitation posters that were displayed throughout the building, and flyers that were handed out to residents, describing the day and time that the research team would be present to administer the questionnaires. After obtaining informed written consent, data collection was performed by trained research assistants, on paper, due to low educational levels and poor health literacy of participants.[11] The research assistant read each question to the participant, including the answer categories and prompts, and noted the participant's responses. A consecutive sampling method was used, due to the difficulty of surveying in this vulnerable population.[11] Upon completion, the participants were provided with a local grocery gift card worth $10.

Program Costs:

In all communities that took part in the CP@clinic RCT it was found that the local housing authority routinely did not charge for space when other publicly funded or nonprofit organizations were providing health and wellness programming to residents. It is not within the mandate of regional or municipal housing organizations to provide health-related services,[12] but they recognize the value of these types of programs for residents, so they welcomed CP@clinic using the space in-kind. Direct program costs of running CP@clinic included the vehicle to transport the community paramedics between their base and each of the intervention buildings, technology-related costs (software, information technology support, database administration, and YubiKey), and session equipment (laptop, weighing scale, tape measure, blood glucose measurement items, WatchBP Office blood pressure monitoring device, and a carry bag).

Staffing Costs:

Paramedic services are responsible for all of these costs. These included salaries, materials for session implementation and technology-related costs. Where possible, costs were obtained from the source from which the service, object or goods were obtained. Detailed records were kept of all materials required for the implementation of the program. These records were validated with community paramedic supervisors. Staffing hours and salary levels were also verified with paramedic services. Paramedic salary hourly costs were obtained from paramedic

services implementing CP@clinic and where unknown, the highest salary from other services was used. The combined hourly cost of supervision and administration within the paramedic service to oversee the community paramedics was estimated at 200% of paramedic hourly salary with benefits based on information provided by the services. Paramedic vehicle and vehicle-related costs (i.e. mileage to cover maintenance and fuel) were also obtained from the paramedic services directly. Since the paramedic services implementing CP@clinic had different paramedic salary rates, staffing models (dedicated community paramedics versus paramedics on modified duty), and vehicle-related costs, the **total actual costs for all five RCT sites together were used to evaluate cost-effectiveness**. Also, in order to inform paramedic services considering implementing CP@clinic in the future, the costs for each staffing model observed during the RCT have been presented as a sensitivity analysis with three potential staffing models below. Note that staff placed on modified duties are those who are unable to do regular paramedic duties because of temporary physical/mental health conditions.

1) Model 1 (minimum): Two paramedics staffing CP@clinic, both on 'modified' duties, therefore not requiring additional salary costing; 1 hour per week of administrative time; and other staffing (e.g. database management) provided in-kind or funded by external sources.
2) Model 2 (moderate): Two paramedics staffing CP@clinic, but one paid as a community paramedic, and one on modified duties; 1.5 hours per week of administrative time, and the cost of other staffing split 50/50 between the paramedic service and external/in-kind funding.
3) Model 3 (maximum): Two paramedics staffing CP@clinic, both paid as community paramedics; 2 hours per week of administrative time, and the full cost of other staffing being paid for by the paramedic service.

Since the paramedic service perspective has been taken, the healthcare costs examined in this paper do not go beyond the EMS call (e.g. hospital admissions, duration of stay, specialist visits). Data on the number of EMS calls avoided were taken from the RCT results (see Table 1), which found that the intervention buildings had 10.8 fewer calls per 100 apartment units post-intervention, compared to control buildings. The costs (in Canadian dollars) estimated for potential EMS call offset were obtained from Canadian literature in 2017 where we found $499/call to be a minimum cost, $1626/call to be a moderate cost, and $2254/call to be the maximum cost.[13] Inflation according to the Consumer Price Index for Healthcare, [14] was not required since the one-year intervention was in 2015/2016. The base case cost-utility analysis was conducted without any cost offset from the avoided EMS calls and then a sensitivity analysis was conducted using a range of potential cost offsets depending on the value assigned to the average EMS call.

Outcomes

The main outcome was QALY gained (change from baseline) in the intervention buildings compared to the control buildings, over the 1 year intervention period. This was used because of the difference in the utilities of participants at baseline.[15] The cost-effectiveness outcomes were analyzed and presented as incremental cost-effectiveness ratios (ICERs) of the

intervention (CP@clinic) versus control (usual care). Cost-effectiveness, in the form of a cost-utility analysis, was evaluated based on the cost of implementing and maintaining the CP program and QALYs as the measure of effectiveness; sensitivity analyses also included EMS calls avoided in the ICER calculation. ICERs were presented where appropriate (when the intervention was not dominant/dominated). The time horizon of the analysis was 12 months, therefore discounting techniques were not used.

Analysis

The value of the total number of QALYs was calculated by computing the mean QALYs change from baseline during the program period (1-year). The raw EQ-5D-3L survey responses were treated as five-digit vectors (e.g. 13415) and transformed into index scores using the previously validated Canadian EQ-5D-3L value sets.[16] QALYs gained were analysed between the groups at post-intervention, controlling for pre-intervention values and building pairing. Missing QALY values were calculated using multiple imputation techniques (iterative Markov chain Monte Carlo method). Age, education, presence of chronic diseases (hypertension, heart disease, diabetes, high cholesterol, previous stroke), gender, living arrangement (living alone, marital status), baseline EQ5D measures (by individual domains), and baseline utility were used to impute for the missing utility values.

Cost of the program per resident was calculated by dividing the total program cost (summation of all program expenses) divided by the number of units in the intervention buildings. This provided a conservative estimate of the cost per resident since over 90% of units only had one resident [3]; as the number of residents per unit increases, the cost per resident decreases, therefore assuming one resident per unit is the most conservative approach to estimating the cost per resident with fluctuating building resident numbers. The incremental cost per QALY was the ratio of the difference in cost of the CP@clinic per building resident compared to the control group ($0 was assumed because there was no program added) divided by the difference in mean QALY gained in the intervention group compared to the control group. In addition, we conducted Bootstrap Probabilistic Sensitivity Analysis (PSA) using 1000 bootstrap samples of the complete case dataset of post-intervention utility (controlling for baseline values using regression) to determine the uncertainty around the ICER. We created a cost-effectiveness acceptability (CEA) curve based on the PSA analysis to show the probability of the program being cost-effective based on the willingness to pay. Also, potential net program costs were calculated based on the range of costs that could be assigned to each EMS call avoided.

We used the ICER threshold of $50,000 CDN per QALY, which has been suggested as a conservative lower boundary for a willingness to pay threshold.[17]

The program cost per EMS call avoided was the ratio of total program cost over the total number of EMS calls avoided. Finally, the potential net cost for a future site wanting to implement the CP@clinic program in two buildings and in four buildings was calculated for each of the three different staff costing scenarios and each of the three cost-offset scenarios.

RESULTS

Main Trial Results: As published previously, the CP@clinic RCT demonstrated significantly reduced EMS calls after 1 year of implementation when adjusted for the study design (i.e. building pairing) and baseline calls in the sensitivity analysis.[3] Comparing intervention and control buildings, there was an adjusted mean monthly difference of -0.90 calls per 100 apartment units per month (95%CI = -1.54 to -0.26), which translates to an estimated 10.8 fewer EMS calls per 100 apartment units per year (see Table 1). Since the intervention buildings had 1461 units, it can be estimated that 157.8 EMS calls were avoided during the intervention period.

Table 1: Difference in emergency medical service call rates for intervention and control buildings (main trial results)

	Intervention Buildings Mean (SD)	Control Buildings Mean (SD)	Mean Difference (95% CI)
Baseline: Unadjusted monthly EMS calls per 100 units	4.13 (2.79)	4.60 (2.80)	-0.47 (-1.12 to 0.18)
After 1 year: Unadjusted monthly EMS calls per 100 units	3.67 (2.75)	4.79 (2.93)	-1.12 (-1.78 to 0.46)
Unadjusted: Monthly Mean Difference	-0.47 (3.83)	0.19 (3.57)	-0.65 (-1.51 to 0.20)
Adjusted:** Monthly Mean Difference	------	-----	-0.90 (-1.54 to -0.26)*
Expected annual decrease in 911 calls: 10.8 calls / 100 apartment units / year			

Notes: EMS = Emergency Medical Service; n = 26 buildings (13 pairs of intervention and control buildings);
* $p < 0.006$; ** adjusted for building pairing and pre-intervention baseline

In addition, the CP@clinic intervention had a positive effect on resident health-related quality of life in the intervention buildings, compared to the control buildings (see Table 2); this is a building-level result that includes individuals from the intervention buildings, regardless of whether or not they opted to attend the program sessions. A total of 358 residents from intervention buildings and 320 residents from control buildings participated in the survey prior to the start of the intervention (pre-intervention). At 1 year post-intervention, 196 residents from the intervention buildings and 125 residents from the control buildings completed the survey again due to some having moved, died or being lost to follow up (see Figure 1). Resident demographics per site are shown in Supplementary Table 1. Multiple imputation was used to account for the missing data in the sensitivity analysis.

Table 2: Difference in QALY for intervention and control buildings

	Intervention Building Residents versus Control Building Residents		
	Intervention Mean (SD)	**Control Mean (SD)**	**Mean Difference (95% CI)**
MAIN TRIAL RESULTS With multiple imputation (intention-to-treat)	n=358	n=320	
Adjusted[a] QALY: Post-intervention EQ-5D index score, regression adjusted for baseline score and building pairing	0.75 (0.23)	0.71 (0.24)	0.04* (0.00, 0.08)
BOOTSTRAPPING Without multiple imputation (complete case)	n=196	n=125	
Adjusted[a] QALY: Post-intervention EQ-5D index score, regression adjusted for baseline score	0.752 (0.17)	0.703 (0.17)	0.05* (0.01, 0.09)
Bootstrap Probabilistic Sensitivity Analysis: Adjusted QALY (post-intervention EQ-5D index score, regression adjusted for baseline score)	0.744 (0.07)	0.715 (0.08)	0.03* (0.01, 0.04)

Notes: QALY = Quality-Adjusted Life Year; *$p < 0.05$; [a]Intervention and Control EQ-5D index scores were found to be significantly different at baseline, despite randomization, therefore baseline differences were accounted for by adjustment using regression

At the end of the 1-year intervention, when adjusting for baseline differences in the EQ-5D index score between the intervention and control buildings and for building pairing using regression, there was a significant adjusted mean 0.04 QALY change per person (95% CI, 0.00 to 0.08).

Program Costs

Direct costs: The direct program cost of CP@clinic per community was $12,962, and the overall direct program cost for the five communities in the RCT was $64,810, excluding staffing. Please see Table 3 for the list of costs per item and source.

Table 3: Direct Program Costs in Canadian Dollars (excluding staffing)

Item	Source	Cost per site ($ CAD in 2016)
Space	Housing authority of each community	In-kind
Vehicle incl. fuel and maintenance	Paramedic service of each community	10,000
Information technology supports and overheads	McMaster University, DFM IT	500
Database software	McMaster University, DFM IT	235
YubiKey	McMaster University, DFM IT	53
Printing and materials (e.g. posters, flyers, BP record card)	McMaster University Media Services	253
Session Equipment:		
Laptop	McMaster University, DFM IT	726
Weighing scale	Medical supply vendor	240
Tape measure	Medical supply vendor	5
BP machine (WatchBP Office)	Medical supply vendor	750
Glucometer, lancets, swabs, bandages	Paramedic service of each community	150
Carry Bag	Office supply vendor	50
	Direct program costs per community:	12,962
	Total direct program costs for all five RCT study sites:	**64,810**

Notes: BP = Blood pressure; DFM IT = Department of Family Medicine Information Technology; RCT = Randomized Controlled Trial

Staffing costs**:** Each site had different staffing arrangements during the RCT, such as rate of pay, number of buildings receiving the intervention, and number of paramedics on modified duties staffing the wellness clinics (see Supplementary Table 2). Therefore, the actual staffing costs for each of the five sites ranged from $5,499 to $25,165, for a total staffing cost of $63,652 for the RCT implementation year (see Table 4). In addition, a sensitivity analysis of potential staffing costs based on assumptions described in the methods. If a future site wanted to implement the program in two buildings, the estimated staffing costs would be $5,499 using the minimum assumptions, $31,745 using the moderate assumptions, and $57,990 using the maximum assumptions (see Table 4). Furthermore, if a future site wanted to implement the program in four buildings, the estimated staffing costs would be $5,499 using the minimum assumptions, $53,741 using the moderate assumptions, and $101,982 using the maximum assumptions.

Table 4: Program Staffing Costs in 2016 Canadian Dollars

	Total Staffing Costs as Implemented During RCT (5 Sites)	Potential Staffing Costs For A Future Site With 2 Buildings	Potential Staffing Costs For A Future Site With 4 Buildings

Additional Paramedic Staff:*			
Number of buildings implementing CP@clinic	13	2	4
Cost of additional paramedic staff per year (50 weeks, hourly salary including benefits ranged from $50.33 to $54.99 per hour)	$31,130	-----	-----
- Actual: as implemented during the trial	-----	$0	$0
- Minimum: two paramedics on modified duties	-----	$21,996	$43,992
- Moderate: one funded CP, one paramedic on modified duties	-----	$43,992	$87,984
- Maximum: two funded CPs			
Additional Supervision and Administration:			
Cost of additional supervisory and administrative staff hours per year (50 weeks)	$32,522	-----	-----
- Actual: as implemented during the trial	-----	$5,499	$5,499
- Minimum: 1 hour per week	-----	$8,249	$8,249
- Moderate: 1.5 hours per week	-----	$10,998	$10,998
- Maximum: 2 hours per week			
Other staffing (program evaluation, data repository, training development):			
Cost of other staffing ($3,000/year base cost)			
- Actual: as implemented during the trial	$0	-----	-----
- Minimum: Funded entirely from external source or in-	-----	$0	$0
kind	-----	$1,500	$1,500
- Moderate: 50/50 mixed funding model	-----	$3,000	$3,000
- Maximum: Funded entirely by the paramedic service			
TOTALS:			
- Actual costs during RCT (5 sites)	**$63,652**	-----	-----
- Minimum Assumption Scenarios (1 site)	-----	**$5,499**	**$5,499**
- Moderate Assumption Scenarios (1 site)	-----	**$31,745**	**$53,741**
- Maximum Assumption Scenarios (1 site)	-----	**$57,990**	**$101,982**

Notes: *Paramedic staff funded specifically for the Community Paramedicine role and not on modified duty; CP = Community Paramedic

Total program costs: Taking the direct program costs ($64,810) together with the staffing costs ($63,652), the actual cost of running the intervention in all five RCT sites for one year was $128,462. Under the different staffing assumptions, the total program costs for one community planning to implement CP@clinic in the future would be expected to range from $18,461 to $70,952 for two buildings and from $18,461 to $114,944 for four buildings.

Given that there were 1,461 apartment units in the intervention buildings and using a conservative estimate of one resident per apartment unit (more than 90% of the building residents live alone[3]), the total program cost per resident was $88 for this RCT. For each site, the program cost per resident ranged from $35 to $292. This calculation assumed that all residents had the potential to attend the program, whether they did or not, as per our other costings. In addition, the total program cost per EMS call avoided was $814.

Cost-Utility Main Analysis

The CP@clinic RCT found a gain of 0.04 QALY per intervention building resident (see Table 2). Therefore, the program cost per QALY gained of the CP@clinic intervention was $2,200 (see Table 5). This value was well below the $50,000 willingness to pay threshold commonly suggested for health intervention cost-effectiveness.

Table 5: Cost-utility analysis of CP@clinic Intervention in 2016 Canadian Dollars

QALY Change Per Resident	0.04	
Program Cost Per Resident for full RCT (direct costs and staffing of $128,462 for 1461 units)	$88	
Base Case ICER (Program Cost per QALY)	$2200	
Probabilistic Sensitivity Analysis using Bootstrapping		
QALY Change Per Resident (95% Confidence Interval)	0.03 (0.01, 0.05)	
Program Cost Per Resident by Site	$35 - 292	
Mean ICER (Fieller's 95% Confidence Interval)	$4645 ($2489, $10,127)	
Analysis including Potential Cost Offset due to EMS Call Reduction*		
Minimum Assumption: $499/EMS call		
- Cost offset per resident	(-$54)	
- ICER (Cost per QALY)	$850	
Moderate Assumption: $1626/EMS call		
- Cost offset per resident	(-$176)	
- ICER (Cost per QALY)	(-$2,200)	(Intervention Dominant)
Maximum Assumption: $2254/EMS call		
- Cost offset per resident	(-$243)	
- ICER (Cost per QALY)	(-$3,875)	(Intervention Dominant)

Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality-Adjusted Life Year; *Reduction of 10.8 EMS calls per 100 residents

Probabilistic Sensitivity Analysis using Bootstrapping

After the bootstrapping analysis was performed, the CP@clinic RCT found a QALY gain of 0.03 per intervention building resident (see Table 2). The mean ICER with Fieller's 95% CI was $4645 ($2489, $10,127). The CEA curve is presented in Figure 2 with a willingness-to-pay threshold of $50,000 demonstrating that 100% acceptability was achieved well below willingness-to-pay of $15,000.

Cost-Utility Analysis with Additional Cost Offsets

The base case cost-utility analysis reported above did not include any cost offsets. From the perspective of a paramedic service, the potential cost offset due to reduced EMS calls observed in the RCT (main trial results) could vary depending on the value attributed to each EMS call. In the literature, it was noted that the minimum cost of an EMS call in 2017 was $499 CDN, the moderate cost was $1,626 CDN, and the maximum cost was $2,254 CDN).[13] Therefore, due to the reduction of 157.8 EMS calls over the intervention year, the estimated cost avoided during the RCT ranged from $78,742 to $355,681. This resulted in a cost offset of $54 to $243 per resident (see Table 5). Under the minimum cost offset assumption, the ICER was $850, and under both the moderate and maximum assumptions, the intervention was dominant (see Table 5).

Potential Net Program Cost to Paramedic Services

The range of potential program costs if communities were to implement the CP@clinic program in the future would be expected to vary depending on their staffing model. Table 6 shows the matrix of the potential *net cost,* from the perspective of the paramedic service, of implementing CP@clinic in two buildings and in four buildings according to each combination of total program cost and cost offset assumptions. The net potential cost ranges from -$36,259 (capacity saving) to $58,838 for two buildings and from -$90.979 (capacity saving) to $90.716 for four buildings.

Table 6: Potential net program cost for a future paramedic service implementing CP@clinic under different assumption scenarios

		Potential Program Costs - Two Intervention Buildings (Direct costs and staffing)		
		Minimum Assumption ($18,461)	Moderate Assumption ($44,707)	Maximum Assumption ($70,952)
Potential Cost Offsets*	Minimum Assumption ($12,114)	6,347	32,593	58,838
	Moderate Assumption ($39,474)	(-21,013)	5,233	31,478
	Maximum Assumption ($54,720)	(-36,259)	(-10,013)	16,232

Notes: QALY = Quality-Adjusted Life Year; *expected offset for two future buildings, based on the randomized controlled trial results of 157.8 fewer calls in 13 buildings, and a value of $499/call for minimum, $1,626/call for moderate, and $2,254/call for maximum cost offset assumptions

		Potential Program Costs - Four Intervention Buildings (Direct costs and staffing)		
		Minimum Assumption ($18,461)	Moderate Assumption ($66,703)	Maximum Assumption ($114,944)
Potential Cost Offsets*	Minimum Assumption ($24,228)	(-5,767)	42,475	90,716
	Moderate Assumption ($78,949)	(-60,488)	(-12,246)	35,995
	Maximum Assumption ($109,440)	(-90,979)	(-42,737)	5,504

Notes: QALY = Quality-Adjusted Life Year; *expected offset for four future buildings, based on the randomized controlled trial results of 157.8 fewer calls in 13 buildings, and a value of $499/call for minimum, $1,626/call for moderate, and $2,254/call for maximum cost offset assumptions

DISCUSSION

This paper presents a cost-utility analysis of the CP@clinic program with several sensitivity analyses. The incremental cost per QALY for CP@clinic is very reasonable compared to existing Canadian literature on community paramedicine interventions. The ICER of a home visit program in Renfrew County, Ontario has been described to be between $67,000 and $76,000 [8] compared to the CP@clinic ICER of $2,200. The commonly held threshold for willingness to pay for an intervention is $50,000 CDN.[17] The results highlight that through CP@clinic it is possible to not only reduce the number of EMS calls emanating from subsidized (social) housing buildings, but to improve resident health-related quality of life while doing so. This presents an opportunity for health policy to recommend this program for upscale, with vast potential benefits beyond those explored within the scope of this evaluation (e.g. hospitalizations). Considering this empirical evidence, the argument for adoption of the CP@clinic program is very strong.

Our sensitivity analyses present different scenarios that can be taken into account when planning an implementation of CP@clinic. Since the program has fixed implementation costs (e.g. laptop) that could be used for running CP@clinic in many buildings without additional investment, the net program cost for a future site is dependent on the number of buildings in which they will be implementing, as well as the staffing model used. Different assumptions of staffing needed to implement the program and also the potential cost offset have been presented since, in reality, paramedic service organizations had different local solutions for their implementation of the program. Though some implemented CP@clinic with a full staffing complement, others were able to utilize their staff who were on modified duty. Combinations of regular and modified duty staff were also abundant in reality. Some paramedic services noted that the continuity and consistency provided by having the same staff person was beneficial. However the economic savings of using modified staff present an opportunity that cannot be ignored in the practical situation of scarce funding and resources to provide healthcare.[18,19] With this in mind, we would recommend that CP@clinic could ideally be staffed by one funded CP, plus one CP on modified duties; having one consistent CP would help foster a positive relationship between the CP@clinic attendee and the paramedic,[6] and would be more cost-effective than the model using two funded CPs..

Other community paramedicine or similar programs in the literature may not be comparable as they describe substantially different scenarios and contexts. However, they do describe and help with understanding the comparative value of CP@clinic within the arena of health programming. For example, the cost per participant in a Remote Patient Monitoring (RPM) CP program in Southern Ontario was estimated at $1,134.[20] Our cost per resident of $88 is very reasonable and much lower than the cost of remote patient monitoring, which by nature is more labour intensive. If we postulate that we should account for program attendees only, the cost is slightly more at $216 per attendee, which is still much lower than that of the RPM. However, in the case of CP@clinic, the program is offered for all residents of the subsidized housing buildings therefore, we feel it is appropriate to cost it out as though everyone could attend. The RPM program has been documented to avoid up to 26% EMS calls (n=453),[20] and with their overall program cost of $737,100, the cost per EMS call avoided was $1,627. In contrast, CP@clinic has also been documented to avoid a comparable proportion of 19% of EMS calls (n=157.8 calls),[3] at a cost per call avoided of $814, demonstrating that CP@clinic has the ability to be an affordable community paramedicine program.

One of the limitations of this work is that we were unable to account for all loss to follow up through death and moving of residents, due to information constraints. We have potentially underestimated the impact of the CP@clinic program on residents' health and healthcare utilization. We have not formally considered the long-term impacts of the program on the reduction of morbidity, mortality and hospital admission avoidance. This information requires careful linkage to geographical and individual information in order to be able to piece together the long-term picture and was beyond the scope of this economic evaluation. This has been planned for future analysis. Similarly, it was outside of the scope of this study to track the specific nature of the calls made pre- and post-intervention to be able to assign a specific cost to each call. Thus, sensitivity analyses based on the range of potential call values were conducted. Additionally, we have assumed a consistent program effect size for all staffing scenarios, but realistically the effect size may have been greater with more paramedic staff on hand. Future research should determine the implications of different staffing models on the scale of intervention effect. We have also only considered the perspective of the paramedic service since in Ontario they determine how to allocate staff and resource funding to extra programs. The perspective of society or other payers could be considered in future work.

CONCLUSION

In summary, CP@clinic not only avoided 157.8 EMS calls, but improved the quality of life of vulnerable older adults living in subsidized housing. Including the reduction in the EMS calls and their associated costs in the analysis resulted in an intervention that is both cheaper and more effective than usual care. All sensitivity analysis for cost per QALY were below commonly held willingness to pay thresholds indicating that CP@clinic represents value for money.

Author Contributions: GA, RA, MP, and FM were involved in study conceptualization and implementation. RA, GA and MP analyzed and interpreted the data, and DO'R and LT provided guidance in the analysis planning and interpretation. All authors were involved in preparing the paper and approved the final manuscript.

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Conflict of Interest: The authors report no conflict of interest.

Ethics Approval: This study was approved by the Hamilton Integrated Research Ethics Board (#14-210 and #14-645).

Data Sharing Statement: The data that support the findings of this study are not publicly available due to them containing information that could compromise participant privacy. De-identified, limited data will be shared by the corresponding author upon request.

Figure 1. CP@clinic study design and data collection flow diagram
Figure 2. Cost-effectiveness acceptability curve

Legend for Figure 2:

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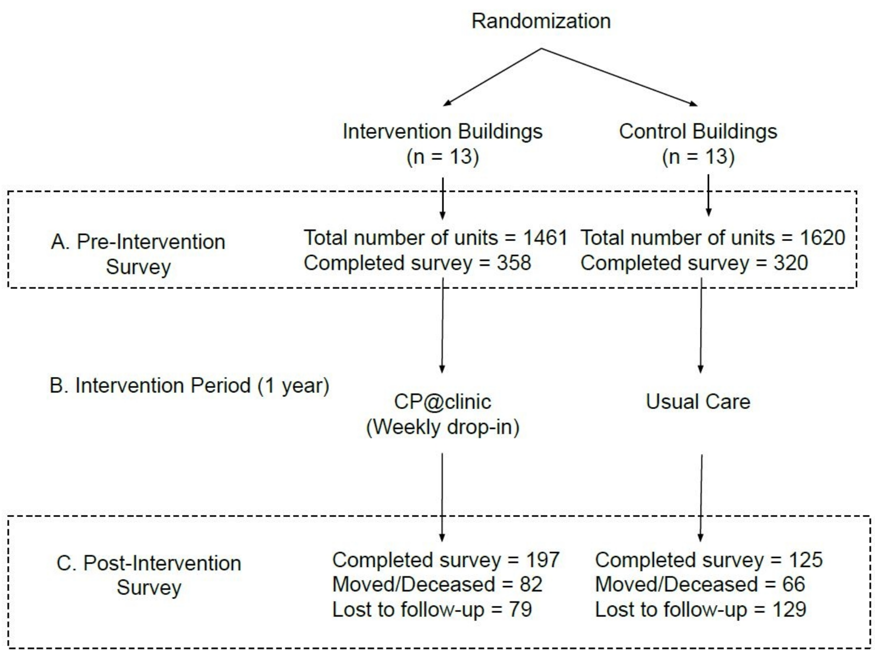

Figure 1: CP@clinic study design and data collection flow diagram

104x75mm (300 x 300 DPI)

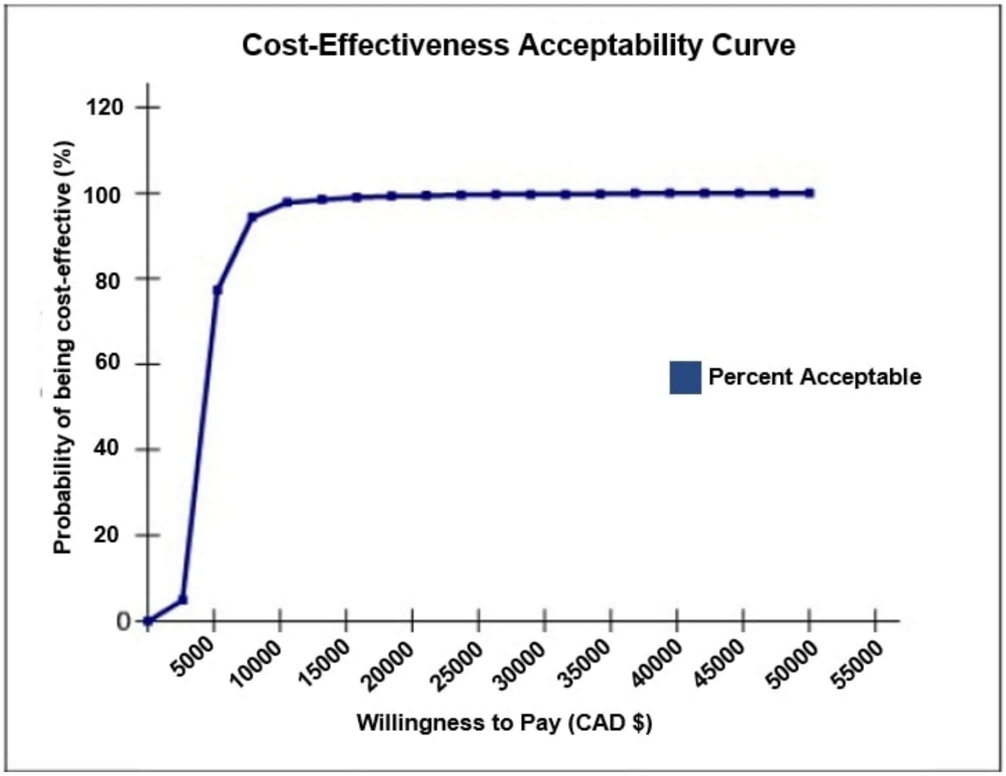

Figure 2: Cost-effectiveness acceptability curve

61x47mm (300 x 300 DPI)

Supplementary Table 1: Individual-level characteristics for intervention and control buildings at baseline

Descriptive Variables	**Intervention building n=358** **n (%)**	**Control building n=320** **n (%)**
Age years: mean (SD)	73.90 (9.05)	70.44 (7.94)
Female	286 (79.9)	229 (71.6)
Lives alone	322 (90.7)	287 (90.0)
Education		
Some High School or lower	160 (45.1)	146 (45.8)
High School Diploma	83 (23.4)	75 (23.5)
Some College/University or Higher	56 (15.8)	50 (15.7)
College or University	56 (15.8)	48 (15.0)
Poor Health Literacy[a]	80 (84.2)	84 (81.6)
With Chronic Diseases		
Heart Problems	111 (31.1)	80 (25.0)
Hypertension	192 (53.6)	177 (55.3)
High Cholesterol	135 (37.7)	119 (37.2)
Stroke	43 (12.0)	39 (12.2)
Diabetes	96 (26.8)	90 (28.1)
Risk Factors		
Low Physical Activity	148 (41.9)	166 (51.9)
Low Fruits and Vegetable intake	123 (34.6)	106 (33.2)
High Alcohol Intake	5 (1.4)	11 (3.4)
Smoker	87 (24.5)	122 (38.4)
High BMI	247 (69.6)	221 (69.0)
CANRISK[b]		
Moderate	104 (39.8)	98 (42.6)
High	151 (57.9)	123 (53.5)
Health Status and Quality-of-Life		
Reported Poor to Fair health	135 (38.0)	139 (43.5)
With mobility problems	218 (61.4)	192 (60.0)
With self-care problems	83 (23.4)	59 (18.4)
With problems doing usual activities	166 (46.8)	133 (41.6)
With pain/discomfort	249 (70.1)	239 (74.9)
With anxiety/depression	176 (48.5)	154 (48.1)
Has a Family Doctor	327 (91.3)	298 (93.1)
EQ-5D Index Score: mean (SD)	0.68 (0.25)	0.70 (0.22)

Notes: [a]For the health literacy assessment n= 89; for intervention 143 for control in Hamilton site only; [b]Only for participant not previously diagnosed with Diabetes

Supplemental Table 2: Actual Program Staffing Costs by Site in Canadian Dollars

	Site #1 4 buildings	Site #2 2 buildings	Site #3 1 building	Site #4 2 buildings	Site #5 4 buildings	All 5 RCT Sites 13 buildings
Number of apartment units:	615	181	101	146	418	
Additional Paramedic Staff:*						
Cost per hour of paramedic staff time, including benefits	$54.95	$50.33	$54.99	$54.99	$54.99	
Hours of additional paramedic staff per year (50 weeks)	0	400	200	0	0	
Subtotal: Paramedic staffing for one year	**$0.00**	**$20,132.00**	**$10,998.00**	**$0.00**	**$0.00**	**$31,130.00**
Additional Supervision and Administration:						
Cost per hour of combined supervision and administrative staff time, including benefits	$109.90	$100.66	$109.98	$109.98	$109.98	
Hours of additional supervisory and administrative staff hours per year (50 weeks)	75	50	50	50	75	
Subtotal: Supervisor and administration for one year	**$8,242.50**	**$5,033.00**	**$5,499.00**	**$5,499.00**	**$8,248.50**	**$32,522.00**
Other staffing (program evaluation, data repository, training development):						
Cost per year for other staff	$3,000.00	$3,000.00	$3,000.00	$3,000.00	$3,000.00	
Percentage of other staffing funded by the paramedic service	0	0	0	0	0	
Subtotal: Other staffing for one year	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
TOTALS:	**$8,242.50**	**$25,165.00**	**$16,497.00**	**$5,499.00**	**$8,242.50**	**$63,652.00**

Notes: *Paramedic staff funded specifically for the Community Paramedicine role and not assigned to modified duties; CP = Community Paramedic

CHEERS Checklist
Items to include when reporting economic evaluations of health interventions

The **ISPOR CHEERS Task Force Report**, *Consolidated Health Economic Evaluation Reporting Standards (CHEERS)—Explanation and Elaboration: A Report of the ISPOR Health Economic Evaluations Publication Guidelines Good Reporting Practices Task Force,* provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	1-2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	30-57
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	95-106
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	110-114
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	102-106
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	102-106, 110-112, 237-239
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	122-127
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	110-122, 152-156. 256-257
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	241-245, 256-257
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	114-116, 142-145
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	110-135

	11b	*Synthesis-based estimates:* Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	N/A
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	N/A
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity cost	189-245
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	N/A
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	189
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	N/A
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	220-235, 241-244
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	259-282
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Tables 1-4, 129-135, 167-173, 287-289, 295-305, 310-320
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Table 5 323-326, 332-341
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact	

		of methodological assumptions (such as discount rate, study perspective).	332-341, 344-349
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	N/A
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Table 4 310-314
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	362-420
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	433-435
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	436

For consistency, the CHEERS Statement checklist format is based on the format of the CONSORT statement checklist

The **ISPOR CHEERS Task Force Report** provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* link or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

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Husereau D, Drummond M, Petrou S, et al. Consolidated health economic evaluation reporting standards (CHEERS)—Explanation and elaboration: A report of the ISPOR health economic evaluations publication guidelines good reporting practices task force. Value Health 2013;16:231-50.

BMJ Open

Cost-effectiveness analysis of a Community Paramedicine Program for low-income seniors living in subsidized housing: The Community Paramedicine at Clinic Program (CP@clinic)

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Cost-effectiveness analysis of a Community Paramedicine Program for low-income seniors living in subsidized housing: The Community Paramedicine at Clinic Program (CP@clinic)

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ABSTRACT

Objectives: To evaluate the cost-effectiveness of CP@clinic compared to usual care in seniors residing in subsidized housing.
Design: A cost-utility analysis was conducted within a large pragmatic cluster randomized controlled trial (RCT). Subsidized housing buildings were matched by socio-demographics and location (rural/urban), and allocated to intervention (CP@clinic for 1 year) or control (usual care) via computer-assisted paired randomization.
Setting: Thirty-two subsidized seniors' housing buildings in Ontario.
Participants: Building residents 55 years and older.
Intervention: CP@clinic is a weekly community paramedic-led, chronic disease prevention and health promotion program in the building common areas. CP@clinic is free to residents and includes risk assessments, referrals to resources, and reports back to family physicians.
Outcome measures: Quality-adjusted life years (QALYs) gained, measured with EQ-5D-3L. QALYs were estimated using area-under-the curve over the 1-year intervention, controlling for pre-intervention utility scores and building pairings. Program cost data were collected before and during implementation. Costs associated with emergency medical service (EMS) use were estimated. An incremental cost effectiveness ratio (ICER) based on incremental costs and health outcomes between groups was calculated. Probabilistic sensitivity analysis using bootstrapping was performed.
Results: The RCT included 1461 residents; 146 and 125 seniors completed the EQ-5D-3L in intervention and control buildings, respectively. There was a significant adjusted mean QALY gain of 0.04 (95%CI:0.00-0.08) for the intervention group. Total program cost for implementing in five communities was CAN$128,462 and the reduction in EMS calls avoided an estimated CAN$256,583. The ICER was CAN$2,933/QALY [bootstrapped mean ICER with Fieller's 95% CI was $4,850 ($2,246, $12,396)] but could be even more cost effective after accounting for the EMS call reduction.
Conclusion: The CP@clinic ICER was well below the commonly used Canadian cost-utility threshold of CAN$50,000. CP@clinic scale-up across subsidized housing is feasible and could result in better health-related quality-of-life and reduced EMS use in low-income seniors.

Strengths and limitations of this study:

- the study is an economic evaluation of a community paramedicine program
- community paramedicine programs are infrequently evaluated from a health economic perspective
- this study adopts the perspective of the paramedic service that might implement such a program
- this evaluation did not include long-term implications of the program and therefore may have underestimated its economic value
- a uniform cost was applied for EMS use despite potential differences due to service or type of call, therefore slight variations in cost remain unaccounted

INTRODUCTION

Community Paramedicine (CP) is an emerging field that is actively expanding across Canada. Community paramedics are deployed in non-traditional, non-acute response settings, which can involve health promotion and disease prevention activities.[1] This new paramedicine role has already demonstrated having a positive impact on the quality of life and health of vulnerable populations,[2,3] while also reducing utilization of emergency medical services.[2,3] In addition, there are potential benefits to the health and wellbeing of paramedics who take on CP roles. [4-6] Though community paramedicine models are emerging widely, evaluation of these programs and activities is rare and those that do exist lack rigour.[1] Evaluation of CP programs should include economic evaluations in order to drive and inform policy change in health authorities. Where these economic evaluations can take account of staffing models, such as modified or non-modified/regular staff, it is even more applicable to healthcare planning.

Though some community paramedicine programs from differing contexts have been evaluated for cost-effectiveness, a recent review for Alberta Health Services concluded that the cost-effectiveness of the CP trials included in their study was not readily generalizable to other settings due to differences in program models.[7] The programs that had a cost-effectiveness evaluation constituted one involving an on-site nurse practitioner-paramedic collaboration and off-site family physician for patients over 40 years of age with chronic disease, and another with a paramedic practitioner for patients over 60 years of age. A recent study conducted in Renfrew County, Ontario, performed an economic evaluation of a home visit program model (Aging at Home) and was able to demonstrate an incremental cost per quality-adjusted life year (QALY).[8] However, no studies have evaluated the cost-effectiveness of a wellness or clinic style community model of community paramedicine.

The Community Paramedicine at clinic program (CP@clinic) has been evaluated in the format of a rigorous randomized controlled trial (RCT), in which the sensitivity analysis found CP@clinic to have positive effects on the reduction of EMS calls from implementation sites, with a reduction of -0.88 calls/month/100 apartment units in Hamilton, and a reduction of -0.90 calls/month/100 apartment units.[2,3] We sought to evaluate the cost-effectiveness of the CP@clinic program compared to usual care for low-income seniors living in subsidized (social) housing using a cost-utility analysis. The perspective of the paramedic service was chosen since it is the implementer of such community programs, and can receive funding from multiple sources, both Ministry and Public payer, depending on its geographic location. Therefore, the paramedic service perspective is the most transferrable, and they would require this type of information to determine future implementation.

METHODS

Design and Setting

This cost-utility analysis (with multiple sensitivity analyses) was conducted from the perspective of paramedic services within the context of a large pragmatic cluster RCT in 2015/2016 for which the protocol [9] and results [3] have been published elsewhere. The one-year RCT

evaluated the CP@clinic program in subsidized housing for seniors (aged 55 and older) in five communities across Ontario, Canada. The cost-utility analysis was conducted alongside the trial, using quality-of-life measures that could be translated into comparable outcomes. Ethical approval was obtained through the Hamilton Integrated Research Ethics Board (study numbers #14-210 and #14-645). Twenty-six subsidized seniors' buildings, matched by socio-demographics and location (rural and urban, Ontario), were allocated to intervention (CP@clinic for 1 year) or control (usual care) via computer-assisted paired randomization. Housing organizations provided building level information which was used in the matching process: proportion of 'older aged' residents, number of units in the building, number of 911 calls per month per 100 units (baseline), and presence of building-level wellness programming. Inclusion criteria were that each building required more than 60% of residents aged 55 years and older, more than 50 residential units, a unique postal code, and had at least one building of similar size and demographic to form a matched pair. There were no exclusion criteria.

Patient and Public Involvement

The broader RCT, through which this data was collected, was first piloted in a single location where building residents (participants) and paramedics had multiple opportunities to shape the future RCT study design and implementation, through comments on the program. Paramedics provided expert advice on the intervention locations (buildings), timing, and session length in social housing. They also advised on their opinion regarding the best method for providing immediate reports to the participants (e.g. printing on-site was not feasible) and sending reports to family doctors. In addition, paramedics informed some of the process metrics collected and disseminated in the study's regular stakeholder reports. Pilot study participants provided input on the best location within the housing building for the sessions, session timing, paramedic consistency (i.e. having the same paramedic each week), and participant resources (e.g. participant card for tracking their goals and measurements). Results were not disseminated to patients, other than each individuals' assessment summary which was provided to them after each session.

Intervention

Standardized weekly CP@clinic sessions were delivered at buildings by community paramedics. A full description of the CP@clinic program is available elsewhere.[2] Risk assessment, disease prevention and health promotion sessions were led by community paramedics, using validated tools focussing on cardiovascular, diabetes, and fall risk. Sessions were open to all building residents and one-on-one and drop-in, taking place in common areas of intervention buildings. After informed consent was taken, paramedics entered data directly into the CP@clinic database, which generated decision support advice. Attendees were counseled on specific lifestyle changes and accessible community resources or relevance Attendees were given a session card outlining their modifiable risk factors and resources that had been discussed. Session summaries were faxed to family physicians, with patient consent. Control buildings received usual care, or services that residents may access by visiting their family physician and ongoing services in their building by local community agencies.

Data Collection

All costs presented are in Canadian Dollars for the 2016 year and represent the costs to the paramedic service implementing CP@clinic (program and staffing costs).

Quality of Life:

Data were collected on quality-of-life from intervention and control building residents before (between October 2014 and December 2015) and after the program (between December 2015 and December 2016). The data collection timing reflected the staggered nature of the RCT starts dates in each site, though at least 12 months was allowed between the before and after surveying. We used the EuroQol Quality of Life Measurement Tool, EQ-5D 3L, by permission.[10] Participants, who were building residents 55 years and older, were invited to complete the survey through invitation posters that were displayed throughout the building, and flyers that were handed out to residents, describing the day and time that the research team would be present to administer the questionnaires. After obtaining informed written consent, data collection was performed by trained research assistants, on paper, due to low educational levels and poor health literacy of participants.[11] The research assistant read each question to the participant, including the answer categories and prompts, and noted the participant's responses. A consecutive sampling method was used, due to the difficulty of surveying in this vulnerable population.[11] Upon completion, the participants were provided with a local grocery gift card worth $10.

Program Costs:

In all communities that took part in the CP@clinic RCT it was found that the local housing authority routinely did not charge for space when other publicly funded or nonprofit organizations were providing health and wellness programming to residents. It is not within the mandate of regional or municipal housing organizations to provide health-related services,[12] but they recognize the value of these types of programs for residents, so they welcomed CP@clinic using the space in-kind. Direct program costs of running CP@clinic included the vehicle to transport the community paramedics between their base and each of the intervention buildings, technology-related costs (software, information technology support, database administration, and YubiKey), and session equipment (laptop, weighing scale, tape measure, blood glucose measurement items, WatchBP Office blood pressure monitoring device, and a carry bag).

Staffing Costs:

Paramedic services are responsible for all of these costs. These included salaries, materials for session implementation and technology-related costs. Where possible, costs were obtained from the source from which the service, object or goods were obtained. Detailed records were kept of all materials required for the implementation of the program. These records were validated with community paramedic supervisors. Staffing hours and salary levels were also verified with paramedic services. Paramedic salary hourly costs were obtained from paramedic

services implementing CP@clinic and where unknown, the highest salary from other services was used. The combined hourly cost of supervision and administration within the paramedic service to oversee the community paramedics was estimated at 200% of paramedic hourly salary with benefits based on information provided by the services. Paramedic vehicle and vehicle-related costs (i.e. mileage to cover maintenance and fuel) were also obtained from the paramedic services directly. Since the paramedic services implementing CP@clinic had different paramedic salary rates, staffing models (dedicated community paramedics versus paramedics on modified duty), and vehicle-related costs, the **total actual costs for all five RCT sites together were used to evaluate cost-effectiveness**. Also, in order to inform paramedic services considering implementing CP@clinic in the future, the costs for each staffing model observed during the RCT have been presented as a sensitivity analysis with three potential staffing models below. Note that staff placed on modified duties are those who are unable to do regular paramedic duties because of temporary physical/mental health conditions.

1) Model 1 (minimum): Two paramedics staffing CP@clinic, both on ‘modified’ duties, therefore not requiring additional salary costing; 1 hour per week of administrative time; and other staffing (e.g. database management) provided in-kind or funded by external sources.
2) Model 2 (moderate): Two paramedics staffing CP@clinic, but one paid as a community paramedic, and one on modified duties; 1.5 hours per week of administrative time, and the cost of other staffing split 50/50 between the paramedic service and external/in-kind funding.
3) Model 3 (maximum): Two paramedics staffing CP@clinic, both paid as community paramedics; 2 hours per week of administrative time, and the full cost of other staffing being paid for by the paramedic service.

Since the paramedic service perspective has been taken, the healthcare costs examined in this paper do not go beyond the EMS call (e.g. hospital admissions, duration of stay, specialist visits). Data on the number of EMS calls avoided were taken from the RCT results (see Table 1), which found that the intervention buildings had 10.8 fewer calls per 100 apartment units post-intervention, compared to control buildings. The costs (in Canadian dollars) estimated for potential EMS call offset were obtained from Canadian literature in 2017 where we found $499/call to be a minimum cost, $1626/call to be a moderate cost, and $2254/call to be the maximum cost.[13] Inflation according to the Consumer Price Index for Healthcare, [14] was not required since the one-year intervention was in 2015/2016. The base case cost-utility analysis was conducted without any cost offset from the avoided EMS calls and then a sensitivity analysis was conducted using a range of potential cost offsets depending on the value assigned to the average EMS call.

Outcomes

The main outcome was QALY gained (change from baseline) in the intervention buildings compared to the control buildings, over the 1 year intervention period. This was used because of the difference in the utilities of participants at baseline.[15] The cost-effectiveness outcomes were analyzed and presented as incremental cost-effectiveness ratios (ICERs) of the

intervention (CP@clinic) versus control (usual care). Cost-effectiveness, in the form of a cost-utility analysis, was evaluated based on the cost of implementing and maintaining the CP program and QALYs as the measure of effectiveness; sensitivity analyses also included EMS calls avoided in the ICER calculation. ICERs were presented where appropriate (when the intervention was not dominant/dominated). The time horizon of the analysis was 12 months, therefore discounting techniques were not used.

Analysis

The QALYs were estimated by assuming linear change and calculating area-under-the-curve (AUC), for the 1-year program period (utility scores at baseline and 1-year post-intervention were summed and then divided by two). The raw EQ-5D-3L survey responses were treated as five-digit vectors (e.g. 13415) and transformed into index scores using the previously validated Canadian EQ-5D-3L value sets.[16] QALYs were regression adjusted for pre-intervention utility scores and building pairing. Missing QALYs were calculated using multiple imputation techniques (iterative Markov chain Monte Carlo method). Age, education, presence of chronic diseases (hypertension, heart disease, diabetes, high cholesterol, previous stroke), gender, living arrangement (living alone, marital status), baseline EQ5D measures (by individual domains), and baseline utility were used to impute for the missing utility values.

Cost of the program per resident was calculated by dividing the total program cost (summation of all program expenses) divided by the number of units in the intervention buildings. This provided a conservative estimate of the cost per resident since over 90% of units only had one resident [3]; as the number of residents per unit increases, the cost per resident decreases, therefore assuming one resident per unit is the most conservative approach to estimating the cost per resident with fluctuating building resident numbers. The incremental cost per QALY was the ratio of the difference in cost of the CP@clinic per building resident compared to the control group ($0 was assumed because there was no program added) divided by the difference in mean QALY gained in the intervention group compared to the control group. In addition, we conducted Bootstrap Probabilistic Sensitivity Analysis (PSA) using 1000 bootstrap samples of the complete case dataset of QALYs (controlling for baseline utility scores and pairing using regression) to determine the uncertainty around the ICER. We created a cost-effectiveness acceptability (CEA) curve based on the PSA analysis to show the probability of the program being cost-effective based on the willingness to pay. Also, potential net program costs were calculated based on the range of costs that could be assigned to each EMS call avoided.

We used the ICER threshold of $50,000 CDN per QALY, which has been suggested as a conservative lower boundary for a willingness to pay threshold.[17]

The program cost per EMS call avoided was the ratio of total program cost over the total number of EMS calls avoided. Finally, the potential net cost for a future site wanting to implement the CP@clinic program in two buildings and in four buildings was calculated for each of the three different staff costing scenarios and each of the three cost-offset scenarios.

RESULTS

Main Trial Results: As published previously, the CP@clinic RCT demonstrated significantly reduced EMS calls after 1 year of implementation when adjusted for the study design (i.e. building pairing) and baseline calls in the sensitivity analysis.[3] Comparing intervention and control buildings, there was an adjusted mean monthly difference of -0.90 calls per 100 apartment units per month (95%CI = -1.54 to -0.26), which translates to an estimated 10.8 fewer EMS calls per 100 apartment units per year (see Table 1). Since the intervention buildings had 1461 units, it can be estimated that 157.8 EMS calls were avoided during the intervention period.

Table 1: Difference in emergency medical service call rates for intervention and control buildings (main trial results)

	Intervention Buildings Mean (SD)	Control Buildings Mean (SD)	Mean Difference (95% CI)
Baseline: Unadjusted monthly EMS calls per 100 units	4.13 (2.79)	4.60 (2.80)	-0.47 (-1.12 to 0.18)
After 1 year: Unadjusted monthly EMS calls per 100 units	3.67 (2.75)	4.79 (2.93)	-1.12 (-1.78 to 0.46)
Unadjusted: Monthly Mean Difference	-0.47 (3.83)	0.19 (3.57)	-0.65 (-1.51 to 0.20)
Adjusted:** Monthly Mean Difference	------	-----	-0.90 (-1.54 to -0.26)*
Expected annual decrease in 911 calls: 10.8 calls / 100 apartment units / year			

Notes: EMS = Emergency Medical Service; n = 26 buildings (13 pairs of intervention and control buildings);
* $p < 0.006$; ** adjusted for building pairing and pre-intervention baseline

In addition, the CP@clinic intervention had a positive effect on resident health-related quality of life in the intervention buildings, compared to the control buildings (see Table 2); this is a building-level result that includes individuals from the intervention buildings, regardless of whether or not they opted to attend the program sessions. A total of 358 residents from intervention buildings and 320 residents from control buildings participated in the survey prior to the start of the intervention (pre-intervention). At 1 year post-intervention, 196 residents from the intervention buildings and 125 residents from the control buildings completed the survey again due to some having moved, died or being lost to follow up (see Figure 1). Resident demographics per site are shown in Supplementary Table 1. Multiple imputation was used to account for the missing data in the sensitivity analysis.

Table 2: Difference in QALY for intervention and control buildings

	Intervention Building Residents versus Control Building Residents		
	Intervention Mean (SD)	**Control Mean (SD)**	**Mean Difference (95% CI)**
MAIN TRIAL RESULTS With multiple imputation (intention-to-treat)	n=358	n=320	
Adjusted[a] QALY: QALY, regression adjusted for baseline utility score and building pairing	0.72 (0.11)	0.69 (0.20)	0.03* (0.01, 0.05)
BOOTSTRAPPING Without multiple imputation (complete case)	n=196	n=125	
Adjusted[a] QALY: QALY, regression adjusted for baseline utility score and building pairing	0.72 (0.09)	0.69 (0.09)	0.03* (0.01, 0.05)
Bootstrap Probabilistic Sensitivity Analysis: Adjusted[a] QALY (QALY, regression adjusted for baseline utility score and building pairing)	0.74 (0.09)	0.71 (0.09)	0.03* (0.01, 0.05)

Notes: QALY = Quality-Adjusted Life Year; *p < 0.05; [a]Intervention and Control EQ-5D index scores were found to be significantly different at baseline, despite randomization, therefore baseline differences were accounted for by adjustment using regression

At the end of the 1-year intervention, when adjusting for baseline differences in the EQ-5D index score between the intervention and control buildings and for building pairing using regression, there was a significant adjusted mean 0.03 QALY change per person (95% CI, 0.01 to 0.05).

Program Costs

Direct costs: The direct program cost of CP@clinic per community was $12,962, and the overall direct program cost for the five communities in the RCT was $64,810, excluding staffing. Please see Table 3 for the list of costs per item and source.

Table 3: Direct Program Costs in Canadian Dollars (excluding staffing)

Item	Source	Cost per site ($ CAD in 2016)
Space	Housing authority of each community	In-kind
Vehicle incl. fuel and maintenance	Paramedic service of each community	10,000
Information technology supports and overheads	McMaster University, DFM IT	500
Database software	McMaster University, DFM IT	235
YubiKey	McMaster University, DFM IT	53
Printing and materials (e.g. posters, flyers, BP record card)	McMaster University Media Services	253
Session Equipment:		
Laptop	McMaster University, DFM IT	726
Weighing scale	Medical supply vendor	240
Tape measure	Medical supply vendor	5
BP machine (WatchBP Office)	Medical supply vendor	750
Glucometer, lancets, swabs, bandages	Paramedic service of each community	150
Carry Bag	Office supply vendor	50
	Direct program costs per community:	12,962
	Total direct program costs for all five RCT study sites:	**64,810**

Notes: BP = Blood pressure; DFM IT = Department of Family Medicine Information Technology; RCT = Randomized Controlled Trial

Staffing costs**:** Each site had different staffing arrangements during the RCT, such as rate of pay, number of buildings receiving the intervention, and number of paramedics on modified duties staffing the wellness clinics (see Supplementary Table 2). Therefore, the actual staffing costs for each of the five sites ranged from $5,499 to $25,165, for a total staffing cost of $63,652 for the RCT implementation year (see Table 4). In addition, a sensitivity analysis of potential staffing costs based on assumptions described in the methods. If a future site wanted to implement the program in two buildings, the estimated staffing costs would be $5,499 using the minimum assumptions, $31,745 using the moderate assumptions, and $57,990 using the maximum assumptions (see Table 4). Furthermore, if a future site wanted to implement the program in four buildings, the estimated staffing costs would be $5,499 using the minimum assumptions, $53,741 using the moderate assumptions, and $101,982 using the maximum assumptions.

Table 4: Program Staffing Costs in 2016 Canadian Dollars

	Total Staffing Costs as Implemented During RCT (5 Sites)	**Potential Staffing Costs For A Future Site With 2 Buildings**	**Potential Staffing Costs For A Future Site With 4 Buildings**

Additional Paramedic Staff:*			
Number of buildings implementing CP@clinic	13	2	4
Cost of <u>additional</u> paramedic staff per year (50 weeks, hourly salary including benefits ranged from $50.33 to $54.99 per hour)	$31,130	-----	-----
- Actual: as implemented during the trial	-----	$0	$0
- Minimum: two paramedics on modified duties	-----	$21,996	$43,992
- Moderate: one funded CP, one paramedic on modified duties	-----	$43,992	$87,984
- Maximum: two funded CPs			
Additional Supervision and Administration:			
Cost of <u>additional</u> supervisory and administrative staff hours per year (50 weeks)	$32,522	-----	-----
- Actual: as implemented during the trial	-----	$5,499	$5,499
- Minimum: 1 hour per week	-----	$8,249	$8,249
- Moderate: 1.5 hours per week	-----	$10,998	$10,998
- Maximum: 2 hours per week			
Other staffing (program evaluation, data repository, training development):			
Cost of other staffing ($3,000/year base cost)			
- Actual: as implemented during the trial	$0	-----	-----
- Minimum: Funded entirely from external source or in-	-----	$0	$0
kind	-----	$1,500	$1,500
- Moderate: 50/50 mixed funding model	-----	$3,000	$3,000
- Maximum: Funded entirely by the paramedic service			
TOTALS:			
- Actual costs during RCT (5 sites)	**$63,652**	-----	-----
- Minimum Assumption Scenarios (1 site)	-----	**$5,499**	**$5,499**
- Moderate Assumption Scenarios (1 site)	-----	**$31,745**	**$53,741**
- Maximum Assumption Scenarios (1 site)	-----	**$57,990**	**$101,982**

Notes: *Paramedic staff funded specifically for the Community Paramedicine role and not on modified duty; CP = Community Paramedic

Total program costs: Taking the direct program costs ($64,810) together with the staffing costs ($63,652), the actual cost of running the intervention in all five RCT sites for one year was $128,462. Under the different staffing assumptions, the total program costs for one community planning to implement CP@clinic in the future would be expected to range from $18,461 to $70,952 for two buildings and from $18,461 to $114,944 for four buildings.

Given that there were 1,461 apartment units in the intervention buildings and using a conservative estimate of one resident per apartment unit (more than 90% of the building residents live alone[3]), the total program cost per resident was $88 for this RCT. For each site, the program cost per resident ranged from $35 to $292. This calculation assumed that all residents had the potential to attend the program, whether they did or not, as per our other costings. In addition, the total program cost per EMS call avoided was $814.

Cost-Utility Main Analysis

The CP@clinic RCT found a gain of 0.04 QALY per intervention building resident (see Table 2). Therefore, the program cost per QALY gained of the CP@clinic intervention was $2,933 (see Table 5). This value was well below the $50,000 willingness to pay threshold commonly suggested for health intervention cost-effectiveness.

Table 5: Cost-utility analysis of CP@clinic Intervention in 2016 Canadian Dollars

QALY Change Per Resident	0.03	
Program Cost Per Resident for full RCT (direct costs and staffing of $128,462 for 1461 units)	$88	
Base Case ICER (Program Cost per QALY)	$2,933	
Probabilistic Sensitivity Analysis using Bootstrapping		
QALY Change Per Resident (95% Confidence Interval)	0.03 (0.01, 0.05)	
Program Cost Per Resident by Site	$35 - 292	
Mean ICER (Fieller's 95% Confidence Interval)	$4,850 ($2,246, $12,396)	
Analysis including Potential Cost Offset due to EMS Call Reduction*		
Minimum Assumption: $499/EMS call		
- Cost offset per resident	(-$54)	
- ICER (Cost per QALY)	$1,133	
Moderate Assumption: $1626/EMS call		
- Cost offset per resident	(-$176)	
- ICER (Cost per QALY)	(-$2,933)	(Intervention Dominant)
Maximum Assumption: $2254/EMS call		
- Cost offset per resident	(-$243)	
- ICER (Cost per QALY)	(-$5,167)	(Intervention Dominant)

Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality-Adjusted Life Year; *Reduction of 10.8 EMS calls per 100 residents

Probabilistic Sensitivity Analysis using Bootstrapping

After the bootstrapping analysis was performed, the CP@clinic RCT found a QALY gain of 0.03 per intervention building resident (see Table 2). The mean ICER with Fieller's 95% CI was $4,850 ($2,246, $12,396). The CEA curve is presented in Figure 2 with a willingness-to-pay threshold of $50,000 demonstrating that 100% acceptability was achieved well below this threshold.

Cost-Utility Analysis with Additional Cost Offsets

The base case cost-utility analysis reported above did not include any cost offsets. From the perspective of a paramedic service, the potential cost offset due to reduced EMS calls observed in the RCT (main trial results) could vary depending on the value attributed to each EMS call. In the literature, it was noted that the minimum cost of an EMS call in 2017 was $499 CDN, the moderate cost was $1,626 CDN, and the maximum cost was $2,254 CDN).[13] Therefore, due to the reduction of 157.8 EMS calls over the intervention year, the estimated cost avoided during the RCT ranged from $78,742 to $355,681. This resulted in a cost offset of $54 to $243 per resident (see Table 5). Under the minimum cost offset assumption, the ICER was $1,133, and under both the moderate and maximum assumptions, the intervention was dominant (see Table 5).

Potential Net Program Cost to Paramedic Services

The range of potential program costs if communities were to implement the CP@clinic program in the future would be expected to vary depending on their staffing model. Table 6 shows the matrix of the potential *net cost,* from the perspective of the paramedic service, of implementing CP@clinic in two buildings and in four buildings according to each combination of total program cost and cost offset assumptions. The net potential cost ranges from -$36,259 (capacity saving) to $58,838 for two buildings and from -$90.979 (capacity saving) to $90.716 for four buildings.

Table 6: Potential net program cost for a future paramedic service implementing CP@clinic under different assumption scenarios

		Potential Program Costs - Two Intervention Buildings (Direct costs and staffing)		
		Minimum Assumption ($18,461)	Moderate Assumption ($44,707)	Maximum Assumption ($70,952)
Potential Cost Offsets*	Minimum Assumption ($12,114)	6,347	32,593	58,838
	Moderate Assumption ($39,474)	(-21,013)	5,233	31,478
	Maximum Assumption ($54,720)	(-36,259)	(-10,013)	16,232

Notes: QALY = Quality-Adjusted Life Year; *expected offset for two future buildings, based on the randomized controlled trial results of 157.8 fewer calls in 13 buildings, and a value of $499/call for minimum, $1,626/call for moderate, and $2,254/call for maximum cost offset assumptions

		Potential Program Costs - Four Intervention Buildings (Direct costs and staffing)		
		Minimum Assumption ($18,461)	Moderate Assumption ($66,703)	Maximum Assumption ($114,944)
Potential Cost Offsets*	Minimum Assumption ($24,228)	(-5,767)	42,475	90,716
	Moderate Assumption ($78,949)	(-60,488)	(-12,246)	35,995
	Maximum Assumption ($109,440)	(-90,979)	(-42,737)	5,504

Notes: QALY = Quality-Adjusted Life Year; *expected offset for four future buildings, based on the randomized controlled trial results of 157.8 fewer calls in 13 buildings, and a value of $499/call for minimum, $1,626/call for moderate, and $2,254/call for maximum cost offset assumptions

DISCUSSION

This paper presents a cost-utility analysis of the CP@clinic program with several sensitivity analyses. The incremental cost per QALY for CP@clinic is very reasonable compared to existing Canadian literature on community paramedicine interventions. The ICER of a home visit program in Renfrew County, Ontario has been described to be between $67,000 and $76,000

[8] compared to the CP@clinic ICER of $2,933. The commonly held threshold for willingness to pay for an intervention is $50,000 CDN.[17] The results highlight that through CP@clinic it is possible to not only reduce the number of EMS calls emanating from subsidized (social) housing buildings, but to improve resident health-related quality of life while doing so. This presents an opportunity for health policy to recommend this program for upscale, with vast potential benefits beyond those explored within the scope of this evaluation (e.g. hospitalizations). Considering this empirical evidence, the argument for adoption of the CP@clinic program is very strong.

Our sensitivity analyses present different scenarios that can be taken into account when planning an implementation of CP@clinic. Since the program has fixed implementation costs (e.g. laptop) that could be used for running CP@clinic in many buildings without additional investment, the net program cost for a future site is dependent on the number of buildings in which they will be implementing, as well as the staffing model used. Different assumptions of staffing needed to implement the program and also the potential cost offset have been presented since, in reality, paramedic service organizations had different local solutions for their implementation of the program. Though some implemented CP@clinic with a full staffing complement, others were able to utilize their staff who were on modified duty. Combinations of regular and modified duty staff were also abundant in reality. Some paramedic services noted that the continuity and consistency provided by having the same staff person was beneficial. However the economic savings of using modified staff present an opportunity that cannot be ignored in the practical situation of scarce funding and resources to provide healthcare.[18,19] With this in mind, we would recommend that CP@clinic could ideally be staffed by one funded CP, plus one CP on modified duties; having one consistent CP would help foster a positive relationship between the CP@clinic attendee and the paramedic,[6] and would be more cost-effective than the model using two funded CPs..

Other community paramedicine or similar programs in the literature may not be comparable as they describe substantially different scenarios and contexts. However, they do describe and help with understanding the comparative value of CP@clinic within the arena of health programming. For example, the cost per participant in a Remote Patient Monitoring (RPM) CP program in Southern Ontario was estimated at $1,134.[20] Our cost per resident of $88 is very reasonable and much lower than the cost of remote patient monitoring, which by nature is more labour intensive. If we postulate that we should account for program attendees only, the cost is slightly more at $216 per attendee, which is still much lower than that of the RPM. However, in the case of CP@clinic, the program is offered for all residents of the subsidized housing buildings therefore, we feel it is appropriate to cost it out as though everyone could attend. The RPM program has been documented to avoid up to 26% EMS calls (n=453),[20] and with their overall program cost of $737,100, the cost per EMS call avoided was $1,627. In contrast, CP@clinic has also been documented to avoid a comparable proportion of 19% of EMS calls (n=157.8 calls),[3] at a cost per call avoided of $814, demonstrating that CP@clinic has the ability to be an affordable community paramedicine program.

One of the limitations of this work is that we were unable to account for all loss to follow up through death and moving of residents, due to information constraints. We have potentially underestimated the impact of the CP@clinic program on residents' health and healthcare utilization. We have not formally considered the long-term impacts of the program on the reduction of morbidity, mortality and hospital admission avoidance. This information requires careful linkage to geographical and individual information in order to be able to piece together the long-term picture and was beyond the scope of this economic evaluation. This has been planned for future analysis. Similarly, it was outside of the scope of this study to track the specific nature of the calls made pre- and post-intervention to be able to assign a specific cost to each call. Thus, sensitivity analyses based on the range of potential call values were conducted. Additionally, we have assumed a consistent program effect size for all staffing scenarios, but realistically the effect size may have been greater with more paramedic staff on hand. Future research should determine the implications of different staffing models on the scale of intervention effect. We have also only considered the perspective of the paramedic service since in Ontario they determine how to allocate staff and resource funding to extra programs. The perspective of society or other payers could be considered in future work.

CONCLUSION

In summary, CP@clinic not only avoided 157.8 EMS calls, but improved the quality of life of vulnerable older adults living in subsidized housing. Including the reduction in the EMS calls and their associated costs in the analysis resulted in an intervention that is both cheaper and more effective than usual care. All sensitivity analysis for cost per QALY were below commonly held willingness to pay thresholds indicating that CP@clinic represents value for money.

Author Contributions: GA, RA, MP, and FM were involved in study conceptualization and implementation. RA, GA and MP analyzed and interpreted the data, and DO'R and LT provided guidance in the analysis planning and interpretation. All authors were involved in preparing the paper and approved the final manuscript.

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Conflict of Interest: The authors report no conflict of interest.

Ethics Approval: This study was approved by the Hamilton Integrated Research Ethics Board (#14-210 and #14-645).

Data Sharing Statement: The data that support the findings of this study are not publicly available due to them containing information that could compromise participant privacy. De-identified, limited data will be shared by the corresponding author upon request.

Figure 1. CP@clinic study design and data collection flow diagram
Figure 2. Cost-effectiveness acceptability curve

Legend for Figure 2:


Percent Acceptable

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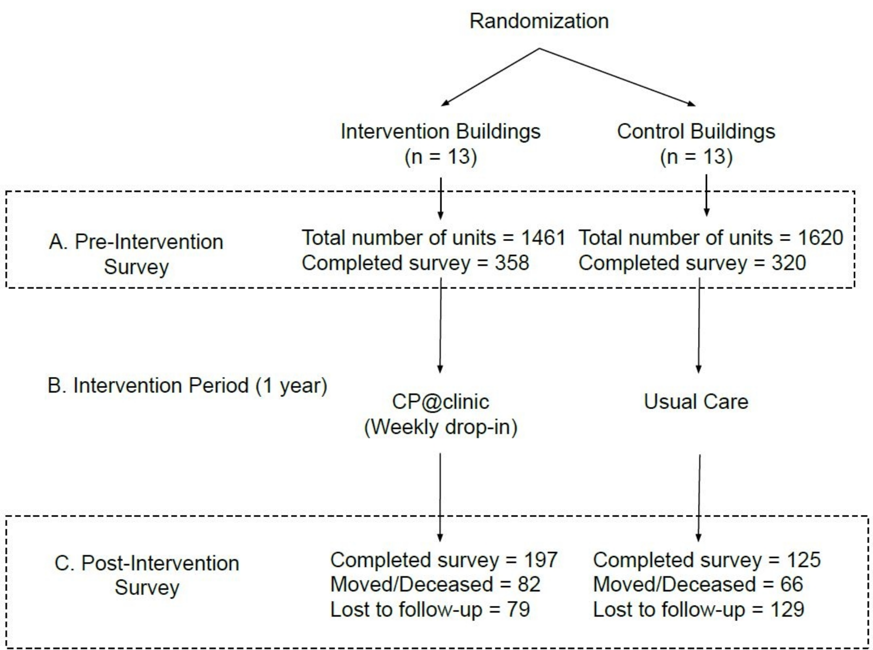

Figure 1: CP@clinic study design and data collection flow diagram

104x75mm (300 x 300 DPI)

Figure 2. Cost-effectiveness acceptability curve

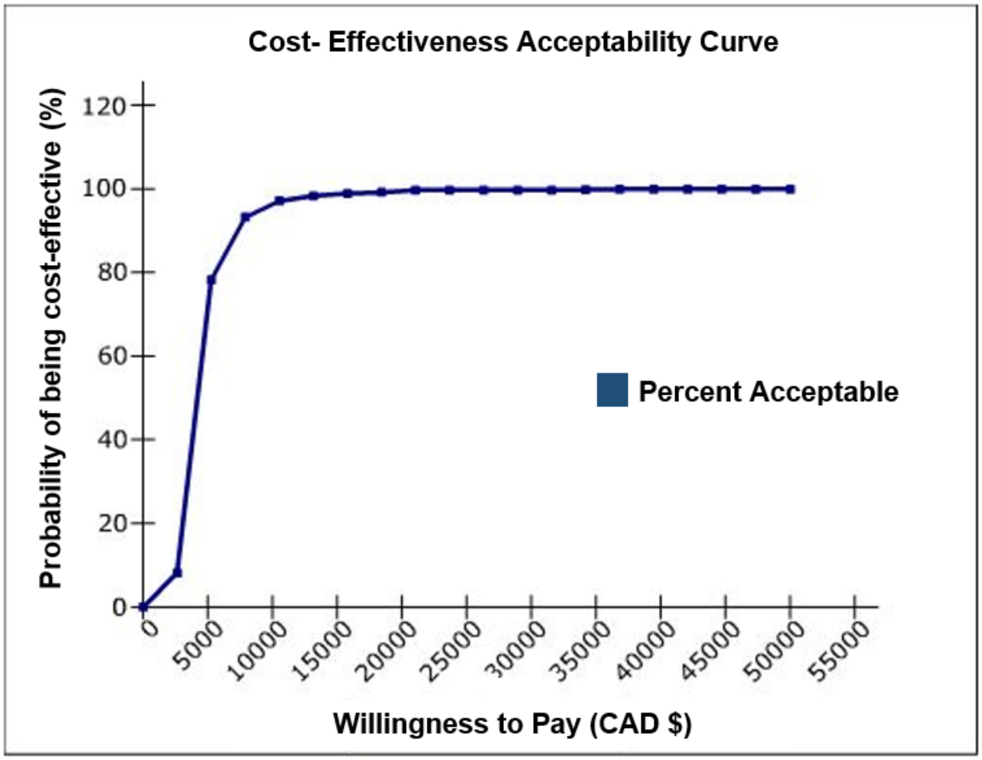

Figure 2. Cost-Effectiveness Acceptability Curve

Supplementary Table 1: Individual-level characteristics for intervention and control buildings at baseline

Descriptive Variables	**Intervention building n=358** **n (%)**	**Control building n=320** **n (%)**
Age years: mean (SD)	73.90 (9.05)	70.44 (7.94)
Female	286 (79.9)	229 (71.6)
Lives alone	322 (90.7)	287 (90.0)
Education		
Some High School or lower	160 (45.1)	146 (45.8)
High School Diploma	83 (23.4)	75 (23.5)
Some College/University or Higher	56 (15.8)	50 (15.7)
College or University	56 (15.8)	48 (15.0)
Poor Health Literacy[a]	80 (84.2)	84 (81.6)
With Chronic Diseases		
Heart Problems	111 (31.1)	80 (25.0)
Hypertension	192 (53.6)	177 (55.3)
High Cholesterol	135 (37.7)	119 (37.2)
Stroke	43 (12.0)	39 (12.2)
Diabetes	96 (26.8)	90 (28.1)
Risk Factors		
Low Physical Activity	148 (41.9)	166 (51.9)
Low Fruits and Vegetable intake	123 (34.6)	106 (33.2)
High Alcohol Intake	5 (1.4)	11 (3.4)
Smoker	87 (24.5)	122 (38.4)
High BMI	247 (69.6)	221 (69.0)
CANRISK[b]		
Moderate	104 (39.8)	98 (42.6)
High	151 (57.9)	123 (53.5)
Health Status and Quality-of-Life		
Reported Poor to Fair health	135 (38.0)	139 (43.5)
With mobility problems	218 (61.4)	192 (60.0)
With self-care problems	83 (23.4)	59 (18.4)
With problems doing usual activities	166 (46.8)	133 (41.6)
With pain/discomfort	249 (70.1)	239 (74.9)
With anxiety/depression	176 (48.5)	154 (48.1)
Has a Family Doctor	327 (91.3)	298 (93.1)
EQ-5D Index Score: mean (SD)	0.68 (0.25)	0.70 (0.22)

Notes: [a]For the health literacy assessment n= 89; for intervention 143 for control in Hamilton site only; [b]Only for participant not previously diagnosed with Diabetes

Supplemental Table 2: Actual Program Staffing Costs by Site in Canadian Dollars

	Site #1 4 buildings	Site #2 2 buildings	Site #3 1 building	Site #4 2 buildings	Site #5 4 buildings	All 5 RCT Sites 13 buildings
Number of apartment units:	615	181	101	146	418	
Additional Paramedic Staff:*						
Cost per hour of paramedic staff time, including benefits	$54.95	$50.33	$54.99	$54.99	$54.99	
Hours of additional paramedic staff per year (50 weeks)	0	400	200	0	0	
Subtotal: Paramedic staffing for one year	**$0.00**	**$20,132.00**	**$10,998.00**	**$0.00**	**$0.00**	**$31,130.00**
Additional Supervision and Administration:						
Cost per hour of combined supervision and administrative staff time, including benefits	$109.90	$100.66	$109.98	$109.98	$109.98	
Hours of additional supervisory and administrative staff hours per year (50 weeks)	75	50	50	50	75	
Subtotal: Supervisor and administration for one year	**$8,242.50**	**$5,033.00**	**$5,499.00**	**$5,499.00**	**$8,248.50**	**$32,522.00**
Other staffing (program evaluation, data repository, training development):						
Cost per year for other staff	$3,000.00	$3,000.00	$3,000.00	$3,000.00	$3,000.00	
Percentage of other staffing funded by the paramedic service	0	0	0	0	0	
Subtotal: Other staffing for one year	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
TOTALS:	**$8,242.50**	**$25,165.00**	**$16,497.00**	**$5,499.00**	**$8,242.50**	**$63,652.00**

Notes: *Paramedic staff funded specifically for the Community Paramedicine role and not assigned to modified duties; CP = Community Paramedic

CHEERS Checklist
Items to include when reporting economic evaluations of health interventions

The **ISPOR CHEERS Task Force Report**, *Consolidated Health Economic Evaluation Reporting Standards (CHEERS)—Explanation and Elaboration: A Report of the ISPOR Health Economic Evaluations Publication Guidelines Good Reporting Practices Task Force,* provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	1-2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	30-57
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	95-106
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	110-114
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	102-106
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	102-106, 110-112, 237-239
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	122-127
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	110-122, 152-156. 256-257
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	241-245, 256-257
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	114-116, 142-145
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	110-135

	11b	*Synthesis-based estimates:* Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	N/A
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	N/A
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity cost	189-245
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	N/A
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	189
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	N/A
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	220-235, 241-244
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	259-282
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Tables 1-4, 129-135, 167-173, 287-289, 295-305, 310-320
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Table 5 323-326, 332-341
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact	

		of methodological assumptions (such as discount rate, study perspective).	332-341, 344-349
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	N/A
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Table 4 310-314
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	362-420
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	433-435
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	436

For consistency, the CHEERS Statement checklist format is based on the format of the CONSORT statement checklist

The **ISPOR CHEERS Task Force Report** provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* link or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

The citation for the CHEERS Task Force Report is:
Husereau D, Drummond M, Petrou S, et al. Consolidated health economic evaluation reporting standards (CHEERS)—Explanation and elaboration: A report of the ISPOR health economic evaluations publication guidelines good reporting practices task force. Value Health 2013;16:231-50.